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(4)

Embankment Criteria and Performance Report

AD-A199 569

W.H. Harsha Lake
Little Miami River Basin
Ohio

July 1988

DEPARTMENT OF THE ARMY
LOUISVILLE DISTRICT, CORPS OF ENGINEERS
P. O. BOX 59
LOUISVILLE, KENTUCKY 40201-0059

CEORL-ED-G

14 September 1988

SUBJECT: Embankment Criteria and Performance Report, William H. Harsha Lake, Ohio

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Aerial View of William H. Harsha Lake

WILLIAM H. HARSHA LAKE
LITTLE MIAMI RIVER BASIN
OHIO

EMBANKMENT CRITERIA AND PERFORMANCE REPORT

Prepared by
U.S. Army Engineer District, Louisville
Corps of Engineers
July 1988

WILLIAM H. HARSHA LAKE
LITTLE MIAMI RIVER BASIN, OHIO
EMBANKMENT CRITERIA AND PERFORMANCE REPORT

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WILLIAM H. HARSHA
LITTLE MIAMI RIVER BASIN, OHIO
EMBANKMENT CRITERIA AND PERFORMANCE REPORT

PERTINENT DATA

1. Authority for Project. Authorized by the Flood Control Act approved 28 June 1938 (Public Law 761, 75th Congress, First Session).

2. Purpose of Project. The principal project purpose is to furnish flood protection in the East Fork and Little Miami River valleys and to reduce flood stages at all points downstream along the Ohio River. The reservoir project is a unit in the general comprehensive plan for flood control and allied purposes in the Ohio River basin. Secondary purposes of the project are to provide storage for water supply and water quality control for recreation and fish and wildlife activities.

3. Location of Project. The dam is located on the East Fork of the Little Miami River about 21 miles above the junction with the main stream near Terrace Park, Ohio. It is located about 25 air miles east of Cincinnati, Ohio.

4. Drainage Area. Damsite - 342 square miles.

5. Reservoir.

	Elevation (feet MSL)	Area Acres	Storage Acre-Feet	Storage Inches Runoff
Siltation Reserve	683	770	18,800	1.03
Water Supply, Water Quality Control	729	2,000	82,200	4.50
Seasonal Pool	733	2,120	90,400	5.08
Flood Pool	795	4,450	284,500	15.60
Allocated to Water Supply and Water Quality Control	683-729		63,400	3.47
Allocated to Seasonal Storage	729-733		8,200	0.58
Allocated to Flood	733-795		194,100	10.52

6. Dam.

a. Embankment.

Type	Earthfill
Top elevation	819
Maximum height, feet	200
Length, feet	1,450
Top width, feet	36

b. Saddle Dam.

Type	Earthfill
Top elevation	819
Maximum height, feet	100
Length, feet	2,600
Top width, feet	30

c. Spillway.

Type	Uncontrolled open cut through left abutment ridge
Crest elevation	795
Bottom width, feet	985
Protection for Spillway cut	Concrete Control Structure

d. Outlet Works.

Type	Oblong, Concrete
Diameter, feet	9.00 x 14
Control gates	2 service, 2 emergency
Size, feet	4.67 x 14
Invert elevation of outlet works at tower	623

7. Land Acquisition.

Fee, acres	10,000

8. Relocation.

a. State Highways	Ohio 222, 0.2 mile
b. County Roads	Clermont County 7 locations, 6.4 miles

c. Electric, telephone and other related utilities as required for the reservoir.

9. Public Access.

Number of sites	4

10. Reservoir Clearing.

Area, Acres	690

11. Hydroelectric Power. None

WILLIAM H. HARSHA
LITTLE MIAMI RIVER BASIN, OHIO
EMBANKMENT CRITERIA AND PERFORMANCE REPORT

1. General.

a. Authority. Authority for preparation of the Embankment Criteria and Performance Report for William H. Harsha is contained in ER 1110-2-1901 dated 31 December 1981.

b. Project Purpose. The principal purpose of the project is to furnish flood protection in the East Fork and Little Miami River valleys and to reduce flood stages at all points downstream along the Ohio River. The reservoir project is a unit in the general comprehensive plan for flood control and allied purposes in the Ohio River basin. Secondary purposes of the project are to provide storage for water supply and water quality control for recreation and fish and wildlife activities.

c. Project Location. The dam is located on the East Fork of the Little Miami River about 21 miles above the junction with the main stream near Terrace Park, Ohio. It is located about 25 air miles east of Cincinnati, Ohio. A reservoir area map and general plan are presented on Plates 1 and 2.

d. History of Construction. The outlets works was constructed by Melbourne Brothers Construction Co., North Canton, Ohio, under Contract No. DACW 27-70-C-0092. The contract was awarded on 4 May 1970 with notice to proceed on 16 May 1970; the official physical completion date was 28 September 1973. The embankment contract was awarded to S. J. Groves and Sons Company of Minneapolis, Minnesota, on 29 December 1972, and notice to proceed was given on 15 January 1973. The Contract No. was DACW 27-73-C-0068. The initial contract time was 1,325 days to which 375 days were added by modifications bringing the completion date to 10 September 1977.

The following is a compilation of significant starting and finishing dates for the main features of the contract.

26 February 1973	-	Survey Party Started Layout
21 March 1973	-	Started Clearing Operations (Spillway)
30 April 1973	-	Started Clearing Operations (Dam)
1 May 1973	-	Started First Stage Temporary Cofferdam (Dam)
5 May 1973	-	Started Clearing Operations (Saddle Dam)
18 May 1973	-	Started Foundation Stripping (Saddle Dam)

6 June 1973	-	Started Piezometer Installation (Saddle Dam)
13 June 1973	-	Completed First Stage Temporary Cofferdam (Dam)
18 June 1973	-	Started Dam Foundation Stripping
20 June 1973	-	Started Drilling and Grouting (Lt. Abutment Dam)
26 June 1973	-	Started Stripping and Excavation Operation in Spillway
30 June 1973	-	Started Blanket Sand Drain Operations (Saddle Dam)
10 July 1973	-	Started Embankment Operations (Saddle Dam)
25 July 1973	-	Drilling and Grouting (Lt. Abutment Dam) Complete
25 July 1973	-	Project Stopped by Restraining Order From Federal Court Relative to Environmental Questions
29 August 1973	-	Resumed Work by Order of Federal Court
10 September 1973	-	Work Stopped by Order of 6th Circuit Court of Appeals
11 September 1973	-	Work Resumed by Orders of 6th Circuit Court of Appeals
12 September 1973	-	Started Installing Settlement Gages Saddle Dam
13 September 1973	-	Started 2 Shift Operation
26 September 1973	-	Started Vertical Sand Drain Saddle Dam
27 October 1973	-	Started First Stage Cofferdam Permanent Dam Embankment. (Inside temporary coffer--river not diverted)
6 November 1973	-	Started Blasting Operations in Spillway
8 November 1973	-	Started Random Earth Fill Dam (Inside first stage temporary coffer)
15 November 1973	-	Second Shift Shut Down for Season
15 November 1973	-	First Stage Temporary Coffer Dam Flooded

25 & 28 Nov 1973	-	First Stage Temporary Cofferdam Flooded
21 December 1973	-	Project Shut Down for Holidays and Winter
1 January 1974	-	Project Shut Down by Wording of Court's Previous Order Concerning Envinronmental Litigation
21 May 1974	-	Stop Order by Federal Court Lifted
28 May 1974	-	Work Resumed (Saddle Dam Embankment and Dam Stripping)
10 June 1974	-	Started Second Shift
20 July 1974	-	First Stage Temporary Cofferdam Flooded
23 July 1974	-	Started Horizontal Blanket Drain Main Dam
12 August 1974	-	Diversion - River was diverted through outlet works
13 August 1974	-	Started First Stage Temporary Coffer Removal
15 August 1974	-	Started Grouting Operations Across Valley Floor
17 August 1974	-	Started Construction of First Stage Permanent Cofferdam
30 August 1974	-	River Overtopped First Stage Permanent Cofferdam (Elev. 658) and Temporary Dike on Top of Coffer (Elev. 658)
6 September 1974	-	Repaired and Resumed Work on First Stage Permanent Cofferdam
11 September 1974	-	Started Embankment Operations on Second Stage Permanent Cofferdam
18 September 1974	-	Started Embankment Random Earth of Third Stage Permanent Cofferdam
20 September 1974	-	Finished First Stage Permanent Cofferdam (Elevation 690)
14 October 1974	-	Started Impervious Core Section Main Dam
17 October 1974	-	Valley Grouting Complete

21 October 1974 -	Started Inclined Drain Material Main Dam
22 October 1974 -	Second Stage Permanent Cofferdam Leveled Off at Elevation 715
6 November 1974 -	Third Stage Coffer Design Changed From Earth Fill to Rock Fill at ± Elev. 675
6 November 1974 -	Started Downstream Rock Embankment Main Dam
26 November 1974 -	Finished Third Stage Permanent Cofferdam (Elevation 737)
18 December 1974 -	End of Second Shift Operation for Season
21 December 1974 -	Winter Shutdown
15 January 1975 -	Resumed Operations (Dam Foundation Excavation and Rock Embankment Dam)
25 February 1975 -	Lake Elevation 696.5 (Crested) Due to Heavy Rainfall
7 April 1975 -	Resumed Embankment Operations Saddle Dam
14 April 1975 -	Started Riprap Saddle Dam
15 April 1975 -	Started Grouting, Right Abutment Dam
21 April 1975 -	Started Second Shift Operation
29 April 1975 -	Started Piezometer Installation Main Dam
3 June 1975 -	Started Spillway Control Sill Excavation
2 July 1975 -	Topped Out Saddle Dam
1 August 1975 -	Finished Grouting Right Abutment Dam
26 August 1975 -	Finished Spillway Control Sill Work
17 September 1975 -	Closed Tower Control Gates to Start Retreat Channel Work in Dry (5 CFS pumped bank to river downstream)
3 October 1975 -	Started Riprap Main Dam
21 November 1975 -	Cancelled Second Shift Operation

22 November 1975 - Retreat Channel Work Complete (Started Releasing Lake, 698.4 Crest)

26 November 1975 - Topped Out Spillway Dike

19 December 1975 - Winter Shut-Down (Main Dam ± 10 Feet From Completion)

15 March 1976 - Work Resumed (Mostly Riprap & Road Work)

5 April 1976 - Topped Out Main Dam

19 November 1976 - Substantial Completion

10 September 1977 - Physical Completion

2. Geology.

a. Pre-glacial Drainage. Prior to the Illinoian Glacial Stage, the drainage pattern was somewhat different than that of today. The present East Fork valley roughly parallels the pre-glacial East Fork valley except at the damsite. The pre-glacial East Fork flowed northwest to the Hamilton-Clermont County line where it met the Little Miami River, then west to the confluence with the ancestral Ohio River and northwest through the normal trough to what is now Mill Creek Valley. The stream united near Elmwood Place with the Licking River from the south, and the combined stream flowed north through what is now Mill Creek Valley and, turning west in the same valley, joined the Miami about 3 miles south of Hamilton. At the project area, the pre-glacial bedrock channel flows west across the saddle dam area then making the bend that the present stream makes. Approximate low point in the pre-glacial channel is believed to be elevation 600± in the saddle dam area. There are no other known pre-glacial bedrock streams in the reservoir area. There is a south flowing pre-glacial channel in which White Oak Creek follows but this channel does not run through the reservoir. A pre-glacial drainage map is presented on plate 8.

b. Glacial History. Glacial deposits found in the general area were laid down during the Illinoian Glacial Stage. The glacial deposits found in the damsite area are primarily clay tills. As the ice sheet advanced southward, the pre-glacial bedrock channel that cuts through the saddle dam was filled with clay till. Clay tills in the uplands were deposited at this time also. The weathered bedrock surface was stripped by the ice and till was deposited on unweathered bedrock. This is the case in the spillway area where clay till lies directly on unweathered interbedded shale and limestone. The clay till has been compacted by the overlying ice and is stiff to very hard. The ice thickness was not as thick as ice farther north, thus the till is not as compact as Wisconsin tills in northern Indiana which were very stiff to hard.

c. Description of Bedrock. Bedrock in the general area is composed of Eden and Maysville Groups. The Eden is found in the stream below the overlying Maysville. Type of rock in both formations is interbedded soft to moderate hard calcareous shale and hard, crystalline, fossiliferous limestone. Limestone beds vary from 0.1 to 1.0 foot thick and are fractured with numerous open vertical joints. The shale is commonly soft 0.1 foot or so below an open limestone joint where water movement has occurred. The Maysville has a higher percent of limestone to shale than the Eden. Structurally, the area is located on the crest of the Cincinnati arch and for all practical purposes, the beds are flat lying. The dominant joint pattern appears to be N-S and E-W.

d. Subsurface Investigations. Overburden was classified from 3-inch drive samples, 6-inch undisturbed Denison samples, and test pits made by a backhoe. The 3-inch drive samples were obtained by using a 5-foot solid barrel drive tube, driven by 325 and 600 pound hammers, with 18- and 12-inch falls, respectively. Hammer size and height of fall are shown on the individual boring logs. The 6-inch flight auger was used initially for borrow area investigations. However, later borrow investigations utilized test pits, dug by a backhoe, and a bucket auger. Several 6-inch flight auger borings were drilled in the saddle dam to supplement drive and core borings. A hollow stem auger was also used in the saddle dam and spillway investigations. Six-inch Denison samples were obtained from beneath the dam and saddle dam areas. Bentonite drilling mud was used in drilled Denison holes. Bedrock was obtained primarily by using an NXM double tube core barrel which yields 2 1/8-inch size core. Nine 6-inch rock core holes were drilled in the dam foundation area. Additional investigations utilizing drive and drive core borings were made along the left abutment access road, control tower access bridge, and the left abutment, downstream diversion dam.

e Damsite Topography. From its source in Clinton County, about 10 miles southeast of Wilmington to Williamsburg, some 30 aerial miles, the East Fork Little Miami River meanders through a glacial drift covered country of low relief with a general course to the southwest. A few miles below Williamsburg it changes its general course from southwesterly to northwesterly. its valley deepens rapidly and for a distance of about 2 miles, it flows essentially on bedrock in a narrow cut gorge. Below the constricted area, the river enters and continues in a broad, deeply filled valley to its junction with the Little Miami River near Milford. The damsite is located in the rock cut gorge section some 6 1/2 miles above Batavia. Topography in the general area is characterized by broad relatively flat drainage divides with numerous small streams and little relief. At the damsite, the left abutment is the downstream portion of a broad flat divide, whereas the right abutment is a long narrow ridge forming the inside of a hairpin bend in the river. There is some 250 feet of relief at the damsite. Bedrock topography of steep smooth slopes is obvious along the side slopes on the right and left abutment. The bedrock on the abutment at the dam is overlaid by 10 to 50 feet of glacial till. North of the saddle dam, typical clay till topography of gentle stream gradients with U-shaped valleys is in evidence. A dendritic drainage pattern has developed in the entire area.

f. Overburden. Types of overburden encountered in the project area are alluvial, colluvial, glacial, and residual.

(1) Alluvial deposits are found under the dam, saddle dam, and the valley bottom borrow areas. A general geologic profile of the dam spillway and saddle dam is included on Plates 9 and 10. Alluvial deposits beneath the dam are 6 to 8 feet of gravel composed primarily of limestone slabs. In the lower portion of the saddle dam, there are 10 to 25 feet of alluvium composed of sandy clay, silty gravelly sand, and silty clay with organic material. This material overlies glacial till and residual clay. In the upstream valley bottom borrow area, there is 5 to 40 feet of alluvium composed primarily of clays and silts.

(2) Along the toe of the left abutment of the dam, there are 20 feet± of colluvial material consisting of lean clay with slabby limestone.

(3) Glacial till, silty sandy clay with some gravel, is found on the flat drainage divides, ridges and in the saddle dam area. It has its greatest thickness north of the saddle dam where it is believed to be 200± feet thick. Along the right abutment ridge, the till is 20 to 65 feet thick. The upper 10 to 15 feet is brown and leached whereas the lower portion is gray and unweathered. On the left abutment, the clay till is 10 to 40 feet thick. The clay till lies directly on bedrock in the upland areas.

(4) Residual lean clay overlying bedrock is found on both steep abutments of the dam and on the left abutment of the saddle dam. The clay is 6 feet thick on the left abutment of the dam, 6 to 15 feet thick on the right dam abutment, and 5 to 10 feet thick on the steep slope of the saddle dam.

g. Bedrock. The Maysville Group and underlying Eden Group of the Cincinnatian Series, Ordovician System, occur at the damsite. Outcrops are scarce, being found only in ravines. Lithology of the two groups is quite similar as was described in the section "Description of Bedrock." The contact between the two groups varies between elevation 697 on the left abutment to a maximum of 706 on the right abutment. This elevation is based on a decreasing percentage of limestone interbeds below elevation 706-697. The Maysville has 20-35 percent limestone interbeds and the Eden has 1 to 20 percent. The dam abutments are founded on the lower Maysville and upper Eden formations. Physical properties are similar for both groups. The rock is fairly erosive but can be cut on steep slopes (where unweathered) for a short period of time before the shale begins to weather, and undercuts the thin limestone interbeds. Along the crest of the narrow right abutment where the shale is overlain by clay till, the rock is unweathered. On the steep side slopes where the till has been removed, the rock has been partially weathered to a depth of 10 to 20 feet. The shales weather to clay or very soft shale, unusually badly stained and leached, and the thin limestone interbeds are stained along open fractures but remain hard.

h. Foundation Conditions.

(1) Dam. The dam was founded on partially weathered shale with 0.1 to 1.0 foot thick limestone interbeds which underlie the zone of primary weathering. The thin limestone beds are fractured and weathered along the open, high angle joint planes. The primary weathered zone varies from 0 in the valley bottom to a maximum of 20 feet on the upper left abutment, and is underlain by soft to moderate hard shale (can scratch with the fingernail with difficulty) with thin fractured limestone interbeds. Average thickness is about 7 feet. Percent core recovery was low in the majority of the NXM holes. It is believed that the core has been ground up in drilling since the 6-inch core holes drilled in the same area had high percentages of recovery. The bulk of the core losses in NXM holes occurred in the weathered and partially weathered zones where the shale was much softer. Drill water return was partially or completely lost while drilling in bedrock in 17 holes beneath the dam. (This includes water losses in the outlet works area.) Thirteen of the borings had water losses occurring within the top 23 feet of bedrock. This would be in the weathered or partially weathered zone. In hole FC-93A, located near the entrance channel for the outlet works, water return was lost 40 feet below top of rock at elevation 607.3. Two other borings, CD-93 and C-93B, lost water in the overburden. Elevations of water losses in other holes under the dam ranged from 602.8 to 667.4, the only consistency being the water was lost in the top 20 feet. In addition, five borings drilled on the abutments but not beneath the dam showed water loss in the upper 20± feet of bedrock. A discussion of and details for the grout curtain are found in Section 3.A.4. Direct shear tests were made on 6-inch bedrock samples taken from six borings located beneath the dam. Cohesion and ϕ angle were determined from these tests, and are considered representative of the bedrock foundation of the dam. Re-evaluation of previously submitted test data (D.M. #3) resulted in lower ϕ angles, but in corresponding higher cohesion values. These values indicated that the foundation bedrock was relatively stronger than the soils used in the embankment. Bedrock contours are shown on Plate 7, "Rock Contour Map." Average bedrock elevation in the valley bottom is approximately 612, and this elevation was used in the stability analyses.

(2) Right Abutment Ridge. The right abutment ridge was investigated for potential leakage zones. Springs were found at the clay till-bedrock contact. In the majority of holes drilled along the ridge, static water stood in the till or at the till-bedrock contact. An exception is DC-84 where drill water was lost at elevation 799.0 and static water stood at elevation 772.4. From a point about 100 feet downstream of boring DC-83 to within 400 feet of the saddle dam, the

highest static water levels along the ridge stood at about elevation 800 or higher. Overburden along the reservoir side of the right abutment ridge from the crest of the ridge to the toe consists of residual clays, impervious colluvium, and glacial till with a combined minimum thickness of 5 to 10 feet. Entrance conditions for reservoir seepage is very poor in these soil types. In addition, bedrock in the abutments is essentially shale with some thin, interbedded limestone. In view of the above, a grout curtain was not considered necessary on the right abutment ridge beyond a point approximately 1,000 feet downstream of the right abutment.

(3) Saddle Dam. The saddle dam primarily was founded on leached to unleached clay till (brown to gray sandy silty clay with a trace of gravel). Along the low point in the saddle, the saddle dam was founded on unleached gray till. At sometime subsequent to the clay till deposition, the till in the low part of the saddle dam was removed by erosion and alluvial material deposited. A third type of soil foundation under the saddle dam is residual lean clay located on the upstream side slope of the left abutment. Bedrock beneath the saddle dam is the Maysville and underlying Eden formations, with the contact at about elevation 700. Between Station 16+00 and the right abutment end of the saddle dam, bedrock falls off to an unknown elevation. Deepest penetration by any boring is DA-115 with a bottom elevation of 615.5. The material in the boring from 689.5 to 615.5 is glacial till. Based on bedrock contours developed by the Ohio Geological Survey in Report No. 10 dated 1959 and titled "Buried River Valleys in Ohio," top of bedrock should be about elevation 600±. Boring DA-115 supports evidence that this pre-glacial valley is till filled and would not be susceptible to any significant seepage which would affect pool levels, or the integrity of the saddle dam. In addition, the seepage path would be approximately 4,000 feet long. Static ground water levels through the dike area generally reflect the topographic slopes at a shallow depth. An exception is boring DA-115, which shows two water levels at considerable depth, 690.5 and 631.0. The water levels in this boring were taken while drilling the boring with hollow stem auger flights, and this type of water level measurement did not truly reflect the static water in relatively impervious overburden. An adjacent water level in boring A-120 is considerably higher, elevation 726.5.

3. Foundation and Abutment Treatment.

a. Main Dam.

(1) Foundation Exploration.

(a) Prior to Construction. A total of 95 exploratory holes or test pits were put down prior to the start of construction between the years 1940 and 1972. The locations of the exploratory holes are shown on Plate 41. Table 1 is a breakdown by type and year.

Two test pits excavated during the construction of the tower and conduit are not listed on the contract drawings. They were put down to explore a reverse fault which was discovered in the excavation for the outlet works in the area of the tower.

(b) During Construction. Eleven core holes were put down on the centerline of the grout line to check areas of significant grout take. All the holes were pressure tested and grouted or backfilled as determined from the pressure test results.

(c) Engineering Properties. The main dam foundation was stripped to unweathered bedrock within the entire limits of the embankment. The overburden testing revealed several weak zones necessitating the total stripping. Foundation soil sections are shown on Plates 15 and 16. The foundation rock will be described in a following section, but is briefly outlined as an interbedded structure of shale and limestone layers. Direct shear tests were made on 6-inch samples taken from six borings located beneath the dam. Cohesion and ϕ angle values were determined to be greater than the embankment strengths. The test results of both the overburden and rock are shown in Table 2.

TABLE 1

SUMMARY OF EXPLORATORY WORK - MAIN DAM

Type	Number & Year								
	1940	1949	1950	1964	1965	1966	1967	1968	1972
C					1	1	2		2
D				1			1		
DC	3			21	27	2		2	
DF					1				
DFC				8	1				
FC		5	4	3	1	3			
TP								2	
UC				4					

C: Core

D: Drive

DC: Drive & Core

DF: Drive & Fishtail

DFC: Drive, Fishtail & Core

FC: Fishtail & Core

TP: Test Pit

UC: Undisturbed & Core

Table 2

SELECTED DESIGN STRENGTH VALUES - MAIN DAM FOUNDATION

MATERIAL	TEST	COHESION (TSF)	FRICTION (DEGREES)
Overburden	Q	0.50	0
	R	0.40	14.0
	S	0.0	21.8
Rock	Direct Shear	1.85 Min.	2.0 Min.
		5.32 Avg.	19.0 Avg.
		15.00 Max.	45.0 Max.

(2) Stripping. The entire foundation was stripped to unweathered rock. The Contractor was given the rule-of-thumb that when he reached the blue shale he was finished. Stripping was generally accomplished with dozers and pans. Depth to unweathered rock ranged from 10 to 20 feet. Approximately 969,701 yards of material were stripped, most of it being wasted. The material from the abutments contained limestone slabs which precluded compaction in the embankments with a tamping roller and the material from the valley was wet. Some stripping material was used in roadway construction. The foundation beneath the permanent cofferdam from the right side of the conduit to Station 106+50 (approximate toe of right abutment) was stripped to elevation 614 to assure removal of the slip plane discovered during construction of the outlet works. This founding elevation necessitated ripping up to 4 feet of unweathered rock from the foundation. The ripped material was utilized in the embankment. No slip plane was observed, but the excavation procedure of ripping eliminated any possible observation.

(3) Foundation Preparation.

(a) Random Rock Zones. Foundation preparation in the rock zones of the embankment was simply dressing the surface with a dozer and rolling with a 50-ton roller. On the abutments, the foundation rock was benched with a dozer blade to insure that any material which had weathered between the time of stripping and the placing of embankment was incorporated in with the fill material.

(b) Random Earth Zone. Preparation in the random earth section of the embankment was similar to that for the rock zone except that weathered material from the abutments was removed and the random earth was placed against a fresh unweathered face.

(c) Impervious Core Zone. Preparation in the impervious zone and the inclined drain area was done with a large Gradall and hand labor. The area was cleaned down to fresh sound rock with the gradall using a smooth lipped 6-foot bucket with laborers working around any limestone ledges. Earth backfill at the faces of any ledges was hand-tamped prior to spreading of an 8 to 12-inch layer of impervious material over the area. The first layer was rolled with a 50-ton rubber-tired roller and then successive layers were placed using a tamping roller. The hauling units were not permitted on the area until approximately 3 feet of material had been placed to protect the bond between the foundation and the fill material.

Approximately 90 percent of the core foundation was shale. The limestone layers in the valley portion were generally removed so as to bond the impervious embankment material to the shale. Most of the limestone was found on the abutments in short stretches where the layers protruded from the shale beds.

No cement mortar was used in foundation preparation as it was easy to remove the limestone pieces back to the shale cover so that no joints nor cracks were exposed. Seepage from the foundation was minor except at the right side of the conduit and a Station 106± on the upstream side of the impervious zone. The seepage at the conduit was controlled by a trench across the section and into the downstream sand blanket at the conduit. When the fill on both sides of the trench was high enough to overcome the head on the seep, the trench was cleaned out with the gradall and impervious material expeditiously compacted on the dry foundation. The seep at Station 106± was ringed off with embankment material until it reached a static head of approximately 6 feet. The sump was pumped dry, the saturated material removed with the gradall and the sides of the sump broken down and compacted. The sump was at the junction of the impervious and the random earth zones.

(d) Downstream Filter Blanket. The downstream half of the foundation was covered with a 3-foot horizontal filter blanket. The foundation rock was dressed with a motor grader and the sand placed directly on the foundation. The material was placed in 1-foot lifts and compacted according to specifications.

Some difficulty was encountered placing the blanket near the downstream toe due to seepage from the Stilling Basin and the Retreat Channel.

(4) Grout Curtain.

(a) General Plan. A single line, two zone, 60 feet deep, stage grouted curtain was constructed at the centerline of the embankment from Station 94+00 to 124+32. The first 370 feet on the left abutment and the last 1,000 feet on the right abutment were offset from the centerline of the roadways to facilitate construction. The holes within the limits of the embankment were put down thru the overburden utilizing casing set into the top of rock. Primary holes were spaced 20 feet center-to-center with successive holes split-spaced down to as close as an 1 1/4-foot spacing. The curtain was zoned into an upper 20-foot depth and a lower 40-foot depth. Where working conditions permitted, the curtain was broken up into 100-foot sections in which grouting operations were not permitted at the same time as drilling. In the shorter working areas, the 100-foot criteria of not drilling and grouting was maintained between individual holes. In general, all grouting in the upper zone in any given section was finished before work was started in the underlying zone. The majority of the grout placed was at a 3 water to 1 cement ratio. Mixes as stiff as a 0.6 water to 1 cement ratio were used in several holes. No sand on mineral filier was used in any of the grout mixes. In general, grout takes were minimal.

Nicholson Ground Archor Company of Pittsburgh, Pennsylvania, performed the work on top of the left abutment from Station 94+00 to 98+60 and at the toe of the left abutment from Station 102+80 to 105+50 during the first season. All grout holes were sealed at top of rock with a packer. A court imposed shutdown at the start of the second construction season prohibited Nicholson from starting up and they left the project. The prime contractor then engaged Continental Drilling of Murraysville, Pennsylvania, to complete the grout curtain. They completed the valley section and the right abutment from Station 105+25 to 112+65 during the second season. The remaining portion of the top of the right abutment and the entire left abutment were completed during the third construction season. Initial stripping for grouting was to top of rock. Final stripping for embankment construction was to sound unweathered rock. The grout curtain profile is shown on Plate 22.

(b) Drilling. The grout holes were drilled with standard rotary drilling equipment without using rod dope. Nicholson used a 3 1/2-inch Tricone bit and a Gardner-Denver ATD 3600 rig to put down their holes. Some difficulty was encountered with the shale clogging the bit until a pump of sufficient pressure and volume to wash the fine shale cuttings away was mobilized. Drill water was obtained from ponds or runoff.

Continental used an EX Fishtail bit with post-mounted air-powered CP-55 drills. Short 2-inch I-D nipples were set 18-24 inches into rock to mount the drill. An airtrack drill and an NX rock bit were used to drill the overburden on the top of the right abutment where casing was set. Drill water was pumped from a storage tank which was filled by the prime contractor's water wagon with river water.

(c) Pressure Testing. Immediately before the pressure grouting of each stage of any hole was begun, the hole was thoroughly washed under pressure and pressure tested. The testing pressure was the same as that for grouting in the two stages. Holes which would not build up any pressure were washed until no signs of cleaning were evident or for a period of 5 minutes at full pump capacity. Holes which tested relatively tight were, at the direction of the Contracting Officer, not grouted in Stage 1 and the hole was taken to grade and then grouted.

(d) Grouting.

(i) Equipment. Both contractors used a Mayno pump to place the grout. The pumps were reliable and did not present any problems. Two circular tubs with rotating stirring paddles were used to mix and/or hold the grout, one always feeding the Mayno pump. A homemade "dip-stick" was used to measure the amount of grout used from the mixing tub in any time period. The grout lines to and from the hole were connected to a "grout tree" by which the pressure into the hole was regulated. No difficulty was encountered in maintaining a constant pressure at the hole. Nicholson used expanding pneumatic packers on all the holes that they grouted; a pressure of 40 PSI was generally sufficient to seal the packer in the hole. Continental tried using mechanical packers, but they would not seal off in the hole; they ended up using a pneumatic packer also with a pressure of 50-100 PSI.

(ii) Pressures. From the start of grouting until 9 October 1974, the upper zone had been pressure tested and grouted at 5 PSI and the lower zone at 10 PSI. The head of the Geology Section of

Foundations and Materials Branch, Engineering Division, reduced the pressures to 3 and 7 PSI, respectively, when it was suspected that the former pressures were lifting the foundation layers. The pressures were monitored at the top of the hole with no corrections for the head due to the grout in the hole.

(iii) Grout Mixes. The majority of the grout placed was at a 3 water to 1 cement ratio. Mixes as stiff as 0.6 water to 1 cement were used to choke off several holes, but this mix was the exception. No sand nor mineral filler was used in any of the grout mixes.

(iv) Grout Injection. After washing and pressure testing of a hole, the packer was set and grout pumped into the hole. All holes were started with a 3 water to 1 cement mix. If the rate of take did not decrease, the mix was stiffened up until such time as a steady or decreasing rate of take was established. A hole was considered finished when it would not take any grout at three-fourths of the maximum pressure for that stage. Occasional leaks which occurred were caulked and/or ringed so as to effect a pressure head. Grout which could not be placed within 2 hours of mixing was wasted.

(e) Exploratory Holes. Eleven core holes were put down along the centerline to check areas of significant grout take. Grout seems were found in each core.

b. Saddle Dam.

(1) Foundation Exploration.

(a) Prior to Construction. A total of 110 exploratory holes or test pits were put down prior to the start of construction between the years 1940 and 1968. The locations of the exploratory holes are shown on Plate 43. Table 3 is a breakdown by type and year.

(b) During Construction. The only holes put down during construction were the pilot holes for the pneumatic piezometers.

(c) Engineering Properties. The foundation materials were sampled and tested during the design stage. The test results are shown in Table 4. The foundation strata can generally be described as:

(i) A leached to unleached brown to gray clay till on the left abutment ridge and the right abutment.

(ii) An alluvial material in the lower part of the valley which was deposited subsequent to the erosion of part of the brown to gray clay till. This strata contains layers and pockets of organic material and extends to depths of 25 feet.

(iii) An unleached gray till which underlays the alluvial material in the lower part of the valley.

(iv) A residual lean clay strata located on the upstream side slope of the left abutment.

TABLE 3

SUMMARY OF EXPLORATORY WORK - SADDLE DAM

Type	Number & Year						
	1940	1949	1964	1965	1966	1967	1968
A			8				
DA			1				
DC	5	1	8	7	3	2	2
D			3	16		7	16
DU						1	
C			1				
FC		1					
FDC			1		1		
FD						1	
RD						3	
TP							13
U			1	2		2	2
UC			1				1

A: Auger

DA: Drive & Auger

DC: Drive & Core

D: Drive

DU: Drive & Undisturbed

C: Core

FC: Fishtail & Core

FDC: Fishtail, Drive & Core

FD: Fishtail & Drive

RD: Rockbit & Drive

TP: Test Pit

U: Undisturbed

UC: Undisturbed & Core

Table 4

SELECTED DESIGN STRENGTH VALUES - SADDLE DAM FOUNDATION

MATERIAL	TEST	C COHESION (TSF)		Ø FRICTION (DEGREES)	
		21+70	23+60	21+70	23+60
Alluvium	Q	0.9	0.9	0.0	0.0
	R	0.2	0.2	16.8	16.8
	S	0.0	---	24.0	----
Alluvium Organic	Q	0.3	0.3	0.0	0.0
	R	0.2	0.4	17.5	15.8
	S	0.0	---	28.5	----
Composite of Alluvium & Alluvium Organic	R&S Avg.	0.11		21.8	

(2) Foundation Stripping. It was originally planned to excavate and waste the alluvial material in the lower valley portion of the saddle dam. This would have involved approximately 165,000 cubic yards of material and depths of up to 25 feet. Additional exploration, testing, and design subsequent to 1968 eliminated the extensive alluvial stripping and substituted a construction sequence which would allow the weak foundation material to remain in place and to consolidate and gain strength during the construction period.

Stripping of all organic material within the area of the saddle dam foundation was specified in the contract documents. The elevations of the stripped valley foundation are shown on Plate 27. The ridges and part of the upper side slopes were successfully cleared and stripped with dozers and pans. The lower slopes, all the valley proper and the drainage draws were too soft to support a D8 dozer and stripping was performed with a large Gradall and a Dragline. Material was excavated and cast up on a ridge where it was loaded in pans. Approximately 40 percent of the material stripped was handled by the Gradall and Dragline. A total of 128,000 cubic yards of material was stripped from the foundation area. Several springs were encountered while stripping. Those on the downstream side were tied into the filter drains; those on the upstream were tied into the 5- x 3-foot sand drain. No pervious material was placed on the upstream side closer than 125 feet to the centerline. A farm pond at approximately Station 13+00 on the downstream side presented some problems during stripping due to the depth of sediment.

Stripped material was placed in the upstream waste berm; some topsoil was stockpiled for later use.

Due to the soft material exposed in the valley proper and in the drainage draws, start of the embankment work was difficult. On the downstream side, the 50-foot wide, 3-foot thick filter drains were placed in a single lift. Compaction was obtained by additional rolling and verified by field density tests. On the upstream side, a 3-foot lift of heavy gray till from the spillway excavation was used to bridge the soft areas.

(3) Inspection Trench. An inspection trench 10 feet deep with a 10-foot bottom width and 1.5:1 side slopes was excavated the entire length of the saddle dam in the valley proper. Excavation was done with a large Gradall; dozers and pans accomplished the rest of the excavation. In the valley proper, the trench exposed, but did not completely sever, a layer of organic alluvial material near Station 22+00.

A layer of water-bearing sand and gravel was exposed near Station 25+00 at approximate elevation 726. It could not be entirely removed and a complete cutoff was not possible. The layer ran back under the right abutment. The trench was pumped and rapidly backfilled with clay, forcing the water to revert to its former course.

4. Slope Stability.

a. Laboratory Tests.

(1) General. Laboratory tests on embankment and foundation materials were performed at the Ohio River Division Laboratories, Cincinnati, Ohio. The testing program included Q (unconsolidated-undrained), R (consolidated-undrained), and S (consolidated-drained) shear, consolidation, permeability and standard properties tests.

(2) Dam Foundation Soils. Three Q, four R, and two S shear tests were performed on soil samples from three undisturbed holes (UC 70, 71 and 72) drilled in the dam foundation. These shear tests were indicative of the low shear strength of the dam foundation soils which consist of silty sand, lean clay, fat clay, and large pockets of organic material. A tabulation of test results are shown in Table 5.

(3) Dam Foundation Rock. Nine direct shear tests were run on 6-inch rock core samples from core holes DC-69, C-93B, C-200, C-207A, C-208, and C-209 in the dam foundation area. Virtually all of the shear test results indicate the rock shear strength is significantly greater than the embankment design shear strength.

(4) Saddle Dam Foundation Soils. Eleven Q, twelve R, eight S, and four unconfined compression tests were performed on soil samples from seven undisturbed holes (U-130, 131, 143, 144, 184, 185, and 190) located throughout the saddle dam foundation area. The shear test data confirmed the weakness of the organic clay zones interbedded within the alluvial infill portion of the saddle dam foundation. The remaining shear tests were run on the inorganic alluvial infill and glacial till materials with the exception of one S test, which was run on a residual clay-shale sample from hole U-130. The S test on the residual clay-shale which was quite low, was discarded because of excessive sample disturbance. A tabulation of test results are shown in Table 6.

(5) Saddle Dam Foundation Rock. No direct shear tests were run on the bedrock in the saddle dam foundation area since the bedrock is at a depth sufficient to preclude any stability problem.

b. Selection of Shear Test Values.

(1) Dam Foundation. The presence of several zones of soft and weak materials throughout the alluvial portion of the dam foundation necessitated stripping of rock thus precluding selection of any adopted design shear strengths. The colluvial foundation adopted shear strengths were based on an average of laboratory test results. These relatively low shear strengths indicate the necessity for stripping the abutments also. Usable materials from the foundation stripping was incorporated in the dam embankment.

(2) Saddle Dam Foundation. The foundation for the saddle dam was divided into three strata, namely: glacial till, alluvial infill, and residual soils.

The adopted Q shear strength of the till (C = 1.00 tsf, tan ϕ = 0.040) was based on an average cohesion intercept of the three triaxial test failure envelopes along with four unconfined compression tests. The low adopted tan ϕ has been taken as an adequately conservative value. The adopted R shear strength of the till (C = 0.80 tsf, tan ϕ = 0.200) was based on an average cohesion and fairly conservative tan ϕ. Adopted S shear strength values (C = 0.00 tsf, tan ϕ = 0.505) were based on an average value of three direct shear tests. The adopted Q (C = 0.85 tsf, tan ϕ = 0.000), R (C = 0.32 tsf, tan ϕ = 0.324), and S (C = 0.00 tsf, tan ϕ = 0.544) shear strength values of the alluvial infill were based on near average values in each particular case. The adopted shear strength parameters of the organic materials encountered in the alluvial infill were taken as the actual shear test results. These Q and R shear strengths of (C = 0.30 tsf, tan ϕ = 0.014) and (C = 0.19 tsf, tan ϕ = 0.309), respectively, were relatively low and typical of organic soils of this type.

The residual soil (clay-shale) samples tested from hole U-130 yielded a low shear strength value which was not assumed valid due to sample disturbance. See Table 7 for the dam and saddle dam foundation test results.

After the presentation of the feature design memorandum, additional drilling was made of the foundation organic infill area. Drilling consisted of drive borings, test pits, and Denison Sampling. Testing consisted of Q, R, and S shear testing, consolidations, and Atterberg Limits for comparison. Table 9 shows the strength ultimately used in the stability analyses.

(3) Embankment Materials.

a. Main Dam. The main dam as presented in the DM was an earth-fill embankment. After preparation of the DM the spillway site was relocated resulting in the availability of a considerable volume of rock (Shale and Limestone) that would have to be wasted. It was decided to rezone the embankment using the available rock. The cross-section was not revised even though it was recognized from previous designs with similar materials that the strengths would be considerably higher than those used originally to establish the cross-section. During construction large scale triaxial testing was performed on rock from the spillway excavation. Stability analyses were performed using these test results for record purposes. The strengths used are listed in Table 8.

b. Saddle Dam. Borrow Material for the Saddle Dam Embankment consisted of impervious fill assumed to come from Borrow Areas E and F in Sheet No. 6. The selected design strengths are shown in Table 9. Design and record shear strength envelopes for the impervious materials are shown on Plates 124 through 126. Design and record shear strength envelopes for the random rock materials are shown on Plates 127 through 133.

TABLE [illegible]

DAM FOUNDATION SOIL TEST DATA

WILLIAM H. HARSHA LAKE

Hole No.	Sample No. & Class	Atterberg Limits LL	Atterberg Limits PL	Nat. Dry Den. (PCF)	Nat. W.C. (%)	Type of Shear Test	Tan Ø	C (T/ft^2)	Permeability Load (T/ft^2)	Permeability K(10^{-4} Ft/Min)
UC-70	1-SC-SM	20.6	14.9			S	0.617	0.00		
						R	0.341	0.00		
						Q	0.169	0.30		
	2-SM					R	0.730	0.00		
						Q	0.355	0.00		
	3-SM			117.5	13.0					
	4-SM				11.9					
	5-SM									
UC-71	1-CL				28.4					
	2-CL				34.6					
	3-CH-CL	54.0	24.8	102.3	24.0	R	0.250	0.40		
						Q	0.065	0.69	0.25	.000081
						S	0.400	0.00	4.00	.000055
UC-72	1-CL-CH	50.3	23.9	95.2	27.2	R	0.250	0.40		
	2-CH				42.4					
	3-CH				24.0					
	4-GC	34.2	17.2							

TABLE [illegible]

SADDLE DAM FOUNDATION SOIL TEST DATA
WILLIAM H. HARSHA RESERVOIR, OHIO

Hole No.	Sample No. & Class	Atterberg Limits LL	Atterberg Limits PL	Nat. Dry Den. (PCF)	Nat. W.C. (%)	Type of Shear Test	Tan Ø	C (T/ft^2)	Permeability Load (T/ft^2)	Permeability K(10^{-4} Ft/Min)
UC-130	1-T				17.8					
	2-CL	40.5	18.6	100.8	24.0	S	0.503	0.00	0.25	.00067
						R	0.351	0.21	4.00	.00033
						Q	0.000	0.53		
	3-SM			23.2						
	4-CL	31.1	17.1	116.2	17.7	S	0.575	0.00	0.25	.00120
						R	0.400	0.34	4.00	.00075
						Q	0.038	0.37		
	5-CL			107.0	22.1				0.25	.00014
									4.00	.00014
	6-CL	43.6	21.5	107.8	21.6	S	0.309	0.00		
UC-131	1-CL			99.5	24.2					
	2-CL	36.0	16.6	105.4	20.0	S	0.540	0.00	0.25	.000260
						R	0.364	0.18	4.00	.000077
						Q	0.020	0.96		
	3-CL				17.7					
	4-SM				13.1					
	5-ML			111.6	19.0	S	0.634	0.00		
	6-SM	37.9	17.7	97.1	21.9				0.25	.00116
									4.00	.00039
	7-OH	70.5	31.8	87.8	32.0	R	0.309	0.19		
						Q	0.014	0.30		
	8-CL	25.2	17.4	102.3	23.6				0.25	.0006
	9-CL	50.9	27.8	79.2	42.0				4.00	.00081
	10-SM				16.1					

TABLE 6 (Cont'd)

Hole No.	Sample No. & Class	Atterberg Limits LL	Atterberg Limits PL	Nat. Dry Den. (PCF)	Nat. W.C. (%)	Type of Shear Test	Tan Ø	C_2 (T/ft^2)	Permeability Load (T/ft^2)	Permeability K(10^{-4} Ft/Min)
U-143	1-CL				25.9					
	2-CL				18.4					
	3-CL				17.3					
	4-CL				17.9					
	5-CL				19.1					
	6-CL									
	7-CL	31.2	14.5	116.1	16.0	Q	0.220	0.20		
						R	0.200	0.80		
U-144	1-SM				7.6					
	2-SP				12.6					
	3-CL	36.0	21.7	96.0	25.5	Q	0.000	0.85		
						R	0.208	0.57		
	4-CL	29.2	20.6	110.5	19.1	S	0.635	0.00		
						Q	0.000	0.65		
						R	0.400	0.20		
	5-CL			126.1	12.1					
	6-CL				11.1					
	7-CL				11.9					
	8-CL				12.3					
	9-CL				12.7					

TABLE [illegible] (Cont'd)

Hole No.	Sample No. & Class	Atterberg Limits LL	Atterberg Limits PL	Nat. Dry Den. (PCF)	Nat. W.C. (%)	Type of Shear Test	Tan Ø	C_2 (T/ft^2)	Permeability Load (T/ft^2)	Permeability K(10^{-4} Ft/Min)
DU-184	1-CL			107.0	17.5					
	2-CL				12.8					
	3-CL	27.3	14.9	108.3	20.7	Q	0.106	1.56		
						S	0.503	0.00		
	4-CL				13.5					
	5-CL				11.2					
DU-185	1-CL									
	2-GM				16.0					
	3-CL				12.8					
	4-SP-SM	27.2	13.0		15.7					
	5-CL				16.3					
	6-SP-SM				15.9					
	7-CL				16.1	UC		0.56		
	8-SC				15.9					
	9-SC				17.6					
	10-CL				18.2					
	11-CL				18.3					
	12-CL				15.3					
	13-CL				16.6					

TABLE [illegible] (Cont'd)

Hole No.	Sample No. & Class	Atterberg Limits LL	Atterberg Limits PL	Nat. Dry Den. (PCF)	Nat. W.C. (%)	Type of Shear Test	Tan Ø	C_2 (T/ft^2)	Permeability Load (T/ft^2)	Permeability K(10^{-4} Ft/Min)
U-190	1-CL				31.8					
	2-CL	47.0	17.5	107.2	18.7	Q	0.075	0.93		
						R	0.225	0.59		
						S	0.440	0.00		
	3-CL	34.4	16.2	108.3	18.9	Q	0.116	0.53		
	4-CL				15.9					
	5-CL	21.9	12.8	120.8	12.6	UC		1.40		
	6-CL			127.4	11.5	UC		1.77		
	7-CL				11.5					
	8-CL				10.0					
	9-CL				11.7					
	10-CL	21.1	12.4	121.8	12.8	UC		1.27		
	11-CL			119.5	13.7					
	12-CL			118.8	14.0	Q	0.044	1.10		

TABLE 7
ADOPTED SOIL DESIGN VALUES
WILLIAM H. HARSHA RESERVOIR, OHIO

Material	γ_D PCF	γ_M PCF	γ_S PCF	γ_B PCF	Shear Values Type Test	Tan Ø	C TSF
Dam							
Foundation (Colluvial)	104.0	127.0	127.0	64.5	Q	0.000	0.50
					R	0.250	0.40
					S	0.400	0.00
Saddle Dam							
Foundation (Alluvial)	103.0	126.0	128.0	65.5	Q	0.000	0.85
					R	0.324	0.32
					S	0.544	0.00
Foundation (Till)	115.0	134.0	136.0	73.5	Q	0.040	1.00
					R	0.200	0.80
					S	0.505	0.00
Foundation (Organic)	88.0	117.0	117.0	54.5	Q	0.014	0.30
					R	0.309	0.19

TABLE 8
SELECTED STRENGTH VALUES - MAIN DAM
WILLIAM H. HARSHA DAM

Material	Type Test	(TSF) Cohesion (c)	(Degrees) Friction (Ø)
Compacted Impervious	Q	0.6	0.0
	R	0.4	17.2
	S	0.0	26.6
Random Rock	Q	.35	31.0
	R	.62	20.3
	S	0.0	41.7

TABLE 9

SELECTED STRENGTH VALUES - SADDLE DAM
WILLIAM H. HARSHA

Material	Type Test	(TSF) Cohesion (c)		(Degrees) Friction (ø)	
Embankment	Q	1.1		0.0	
	R	0.4		17.2	
	S	0.0		26.6	
		Sta 21+70	Sta 23+60	Sta 21+70	Sta 23+60
Alluvium	Q	0.9	0.9	0.0	0.0
	R	0.2	0.2	16.8	16.8
	S	0.0	-	24.0	-
Alluvium Organic	Q	0.3	0.3	0.0	0.0
	R	0.2	0.4	17.5	15.8
	S	0.0	-	28.5	-
Composite of Alluvium & Alluvium Organic	R&S	0.11		21.8	

c. Material Usage. Plates 39 and 40 show material usage charts. The dam design required 3,669,000 cubic yards of random rock and 955,000 cubic yards of impervious and random earth. The saddle dam design required 1,678,000 cubic yards of impervious and random earth. The required excavation from the spillway provided for these needs.

(e) Stability Analyses.

(1) Saddle Dam.

(a.) Stability of Downstream Slope; Station 21+70 Perpendicular Section. At the end of construction conditions (Q test), assuming instantaneous loading of the foundation and no drainage, a 400-foot long by 55-foot high berm gave a value of FS = 1.36. Plate 31 represents this condition and shows the appropriate slopes.

Steady seepage was then analyzed, using an average of the R&S strength data. The results yielded a value of FS = 1.55, with a 60-foot long by 24-foot high berm. This analysis is shown on Plate 35 with the appropriate slopes. This berm was then applied to the end of construction condition and a value of FS = 0.83 resulted. This analysis is shown on Plate 32.

An analysis was made to determine the gain in strength of the foundation as the dam was constructed. The percent consolidation vs. time curve showed that if the construction period was kept to a minimum of 2-1/2 years, the gain in strength of the foundation would be sufficient to yield a value of FS = 1.32. This analysis is shown on Plate 36.

(b.) Stability of Upstream Slope; Station 23+60 Perpendicular Section. To verify the assumption that the downstream slope was critical for EOC conditions, a stability analysis was made on the upstream slope, using the 400-foot by 55-foot berm. A value of FS = 1.74 resulted. It was estimated that a minimum berm, 240 feet by 33 feet would be needed to obtain a FS = 1.30 (assuming instantaneous loading and no drainage). This assumption was based on a 40 percent increase in stability from downstream to upstream configuration.

Sudden drawdown was investigated and results indicated that a 45-foot by 15-foot berm gave a value of FS = 1.21. Plate 33 shows the design recommendation and stability calculations.

This berm was applied to the end of construction condition and a value of FS = 1.07 resulted. Since this value was greater than the value of FS for downstream EOC stability with a larger berm, the construction period of 2.5 years would provide sufficient strength gain to insure stability of the upstream slope at EOC conditions. Plate 34 shows this analysis.

Partial pool was analyzed and the minimum value of FS = 1.38 at pool elevation 750.0 was obtained. This value is 0.12 lower than the minimum of FS = 1.50, but it was felt that as construction progressed, the consolidation process would increase the strength of the foundation sufficiently enough to reach the value of FS = 1.5 when partial pool conditions exist.

Table 10 shows the final design factors of safety.

TABLE 10
STABILITY ANALYSES RESULTS
SADDLE DAM PERPENDICULAR SECTION

Stage of Saddle Dam Development	Factor of Safety
End of Construction - Downstream - Sta. 21+70 400' x 55' Berm	1.36
End of Construction - Downstream - Sta. 21+70 60' x 24' Berm - 2.5 Year Construction Period	1.32
Steady Seepage - Sta. 21+70 60' x 33' Berm	1.55
End of Construction - Upstream - Sta. 23+60 240' x 33' Berm	1.30
End of Construction - Upstream - Sta. 23+60 45' x 15' Berm - 2.5 Year Construction Period	1.30
Sudden Drawdown 45' x 15' Berm Sta. 23+60	1.21
Partial Pool 45' x 15' Berm Sta. 23+60 Elev. 750.0'	1.38

(c.) <u>Stability of Skewed Sections</u>. Stability computations were made along the centerline of the alluvium infill area in order that the failure plane pass through the longest path of the weak material. This required a section skewed from the axis and as such, the embankment was somewhat flatter than the normal section.

<u>Downstream Stability; Station 22+50, Skewed Section</u>.

At the end of construction conditions, the value of the factor of safety was found to be 0.68 with a 60-foot long by 24-foot high berm. Plate 37 shows this analysis.

Steady seepage conditions will provide a value of FS equal to or greater than the value of FS = 1.55 (60 feet long by 24 feet high berm) obtained from the analysis assuming a perpendicular section. The average values of R&S strengths were used in this analysis, resulting in a single layer through which the failure plane was found. The R&S strength parameters of the alluvium and the alluvium organic were almost identical (in fact, the alluvium organic showed somewhat higher values). Thus, any analysis of a skewed section would utilize the same foundation conditions and result in a value of the factor of safety equal to or greater than the value obtained from the previous analysis. It was felt that this value of the safety factor, FS = 1.55, should be used as the controlling value for steady seepage conditions.

An analysis was made to determine the increase in the end of construction FS, to account for the gain in strength as consolidation occurs in the foundation when loaded. It was found that a minimum construction period for 3 years is needed to insure short-term stability (FS = 1.31). The maximum elevation safely obtainable, without assuming strength gain during the consolidation process, is 750.0, where FS = 1.32. This analysis is shown on Plate 36. Various elevations were analyzed to determine a safe height based on increased strength due to consolidation. The following was recommended: the embankment should be built to El 750.0 between Stations 16+20 to 25+20 during the first year. Also, during this first year, the embankment from the beginning Station 4+60 to 12+80 (toeing out on a 5:1 slope to 16+20) and from the end Station back to 28+60 (toeing out on a 5:1 slope at 25+20) was built to full height, El 819. The second was used as a period of consolidation to provide a sufficient gain in strength so that the remainder of the Saddle Dam could safely be built to 819.0 (top of dam) during the third year.

<u>Upstream Stability Analysis; Station 23+50, Skewed Section</u>.

The end of construction conditions were analyzed and the value of FS was 1.03. This analysis is shown on Plate 38.

Sudden drawdown conditions of the skewed section were compared to the conditions used in the analysis of the perpendicular section. It was found that the alluvium organic and the alluvium R strength parameters were almost identical (c = .37 and .21; ϕ = .283 and .303 for alluvium organic and alluvium, respectively). The alluvium organic appears to have a relatively higher combined strength. Therefore, it was felt that any analysis of the skewed section, assuming organic as a continuous layer, would result in a safety factor which is equal to, or more likely greater than, the value of FS = 1.21 obtained previously. To obtain this value, a 45-foot long by 15-foot high berm was required. As consolidation occurs, during the 3-year construction period, the increase in strength, as shown in the downstream analysis, will also occur upstream providing adequate safety. It was recommended that the upstream design include a 45-foot long by 15-foot high berm. Upstream construction was done in a similar manner as required for downstream stability. Table 11 shows the final design factors of safety.

TABLE 11
RESULTS OF SLOPE STABILITY ANALYSES
(SKEWED SECTION)

Stage of Saddle Dam Development	Factor of Safety
End of Construction - Downsteam - Sta. 22+50 60' x 24' Berm Minimum of 3-yr. Construction	1.31
Steady Seepage 60' x 24' Berm	1.55
First Year (Safe El of 750.0')	1.32
End of Construction - Upstream - Sta. 23+50 45' x 15' Berm Minimum of 3-yr. Construction	1.30
Sudden Drawdown 45' x 15' Berm	1.21
Partial Pool 45' x 15' Berm	1.38

(2) Main Dam. Stability analyses were made using the circular and wedge type analysis as outlined in EM 1110-2-1902. Analyses were made for end of construction, steady seepage, sudden drawdown and partial pool using the appropriate values shown in Table 8. Critical failure surfaces were checked manually for all cases. Table 12 displays the results of stability analyses. Plate 30 shows the end of construction manual check.

TABLE 12
STABILITY ANALYSES RESULTS - MAIN DAM
WILLIAM H. HARSHA DAM

Case	Minimum Factor of Safety
End of Construction	2.85 Wedge
Steady Seepage	3.45 Wedge
Sudden Drawdown	2.26 Circle
Partial Pool (El 733)	3.24 Circle

5. Embankments.

All embankments (dam, saddle dam and spillway dike) consisting of earth or rock fill were obtained from the spillway excavation in the left abutment. The average depth of excavation in the spillway was approximately 50 feet with the earth depth being between 20 to 25 feet thick and rock excavation varying between 25 to 30 feet. The saddle dam was constructed entirely of earth fill. The uncompacted saddle dam waste berms were constructed from dam foundation excavation, channel excavation and some spillway excavation.

The soil in the spillway consisted of 6 to 12 inches of topsoil which was stripped and stockpiled for use on the downstream face of the main and saddle dam. Below the topsoil was a 2'± (varied) thickness of silty lean to fat wet clay. The remainder of the soil consisted of a hard dense till. The upper portions were tan to brown caused from staining and weathering; the lower portions were colored gray which was the unweathered till of Illinoian age. The upper soft wet clay was mixed when feasible with the lower drier tills for use in both the dams.

a. Saddle Dam.

1. Impervious Fill

The saddle dam consisted of ± 1,500,000 cubic yards of compacted impervious fill with a five foot wide vertical sand drain and numerous three foot thick, fifty foot wide horizontal finger sand drains. Maximum height of the fill was ± 110 feet at ± Station 22+50. All material for the impervious embankment was obtained from the required spillway excavation. Material was hauled with caterpillar 631, 637, 641 and 666 scrapers. The material was spread in six-inch lifts, disked with a Rome disk and compacted with eight passes of a sheeps-foot roller. The roller used was a Hyster C455A self propelled sheeps-foot. Moisture limitations on the impervious material was + 1 percent above to - 2 percent below optimum. No significant problems were encountered.

2. Vertical Sand Drain

A five foot wide vertical sand drain was constructed from Station 6+00 to 28+00, 20 feet downstream of center line extending from elevation 795 to the foundation.

The procedure for placing the vertical drain was to first completely cover the existing portion of vertical drain with impervious embankment as the fill was brought up. The drain location was then staked and a five foot wide trench was dug with a G1000 Gradall or similar equipment down to the previous top of sand. The top of existing sand was then hand cleaned. The sand was then spot dumped in piles from trucks and placed in the trench with a small backhoe loader bucket. The sand was then flooded with water from a spray-bar attachment on the back of a water truck. It was then rolled with not less than 4 complete passes with a RayGo 410A self-propelled vibratory roller. No significant problems encountered. The sand was supplied by Dravo Corp. of Newtown, Ohio. The drain material was spread with end loaders and dozers.

3. Horizontal Sand Drain (Finger Drains)

A three foot thick horizontal blanket of filter sand was placed on the downstream foundation in the valley proper and up seven drainage draws. The drainage draws were constructed 50 feet wide. The blanket extended from a point 20 feet downstream of centerline, where it tied to the vertical drain, to the toe of the downstream waste berm near the river bank. Two hundred feet of perforated toe drain pipe was installed from the river bank back up the valley to relieve the horizontal blanket. Due to the soft material exposed in the valley proper and in the drainage draws after stripping operations, it was necessary to place the drainage blanket in a single 3 foot lift. Compaction was obtained by additional rolling with the RayCo 410-A, self-propelled vibratory roller after water was added by hose from a tanker truck and verified by field density tests. Horizontal sand drain material was supplied by Dravo Sand and Gravel Co., Newton, Ohio. The drain material was spread with endloaders and dozers.

4. Required Waste Berms (upstream and downstream)

The upstream and downstream waste berms at the saddle dam were constructed of dam and saddle dam foundation strippings and some spillway excavation. The material was spread in ± 1 foot lifts with a dozer and traffic compacted by scrapers hauling the material.

b. Main Dam.

1. Impervious Core

The impervious core along the centerline of the main dam varied from a width of 36 feet at the top of the dam to ±100 feet at the foundation. Upstream and downstream impervious core slopes were 1 horizontal to 7 vertical. The quantity of material in the impervious core was 461,000 CY.

Nearly all the core material was brown glacial till excavated from the required spillway excavation. The material was hauled with Caterpillar 631, 637, 641 and 666 scrapers. The material was spread in six inch lifts, disked with a Rome disk and compacted by eight passes of a Hyster C455A self-propelled sheeps-foot roller. Moisture limitations on the impervious material was +1 percent above to -2 percent below optimum. The material excavated from the spillway was at or near optimum and very little processing was needed. No significant problems were encountered.

2. Random Earth Zone

The random earth zone was handled identical to the impervious core discussed in paragraph (b) above.

The random earth section was changed to rockfill at elevation 675 after the overtopping flood of August 30, 1974, in order to facilitate finishing of the third stage cofferdam before the winter flood season.

3. Random Rock Zones

The random rock consisted of a hard, crystalline fossiliferous limestone with shale and styolite partingsar intermittent shale layers excavated from the required spillway excavation. The shale was a soft clay shale of highly variable thickness. The rock from the spillway excavation was blasted using 20' center to center spacing on the blast holes and a loading of 3/4 lb/ CY of explosives. The material broke up fine enough to be hauled with rubber-tired scrapers. The material was hauled with Cat 631, 637, 641 and 666 scrapers to the embankment. The material was dumped in ±8-inch lifts and levelled with a Cat D-8 dozer. The fill was then rolled with four passes of a Hyster C455A self-propelled sheeps-foot roller and 2 passes with a 50-ton rubber-tired roller pulled by a D-8 dozer. No significant problems were encountered.

4. Inclined Sand Drain & Transition Material

An eight-foot wide inclined sand drain and five-foot wide transition gravel zone were placed immediately downstream of the impervious core. The sand drain and transition zone extended the full length of the dam from elevation 795 to the foundation.

The procedure for placing these zones was to first overbuild the impervious embankment ±5 feet downstream. The one vertical to seven horizontal slope of the downstream edge of the impervious embankment was then cut to correct location with a G1000 Gradall. The 8-foot wide sand drain and 5-foot wide transition gravel were then placed in one foot lifts with a G1000 Gradall or small backhoe and backed up with random rock on the downstream side. Water was then added to the sand zone by means of an offset bar on a water truck. The zones were then rolled with not less than four complete passes with a RayGo 410A self-propelled vibratory roller. No significant problems were encountered. The sand and transition material were supplied by Dravo Corp. of Newtown, Ohio.

5. Horizontal Sand Drain

A three-foot thick horizontal blanket of filter sand was placed over the entire foundation downstream of the impervious core.

The material was end-dumped from trucks and spread in one foot lifts by a D-8 dozer, Cat 977 loader or G1000 Gradall. The sand was then flooded with water and rolled with not less than four passes with a RayGo 410-A self-propelled vibratory roller. The sand was supplied by Dravo Sand and Gravel Co., Newtown, Ohio.

6. Seepage Control.

a. Main Dam

(1) Seepage. Since the dam was founded on bedrock in its entirety and there was a grout curtain under the dam, no significant

foundation seepage was expected. Seepage along the conduit was controlled by backfilling with compacted impervious material. Adequate clearances adjacent to the conduit were provided to allow machine compaction of the backfill.

(2) Horizontal Sand Blanket. A 3-foot thick blanket of filter sand was installed on the downstream side from the core section to the toe in the valley and up the abutments to elevation 795. It drains the inclined drain and any foundation seepage and is itself relieved by the toe drain.

(3) Toe Drain. An 18-inch perforated pipe runs from dam Station 104+25 at 830 feet downstream to Station 107+20 at 870 feet downstream and from Station 108+50 at 830 feet downstream to Station 107+20 at 870 feet downstream. The perforated pipe drains from the manhole at Station 107+20 to the retreat channel in a 24-inch pipe with a flap gate. The outlet invert elevation is 618.0 which is approximately 7 feet higher than the lowest point of the horizontal blanket which means that there will always be a head in the lower horizontal blanket.

b. Saddle Dam.

(1) Seepage. Boring DA-115 supports evidence that the preglacial valley was till filled, and would not be susceptible to any significant seepage which would affect pool levels, or the integrity of the Saddle Dam. In addition, the seepage path would be approximately 4,000 feet long.

Potential seepage under the Saddle Dam is controlled by a series of blanket drains, finger drains, and a toe drain system.

(2) Horizontal Blanket. A 3-foot thick Horizontal Blanket of Filter Sand was placed on the downstream foundation in the valley proper and up seven drainage draws. The blanket extended from a point 20 feet downstream of centerline, where it tied into the Embankment's Vertical Drain, to the toe of the downstream waste berm near the river's bank.

(3) Toe Drain. Two hundred feet of perforated toe drain pipe was installed from the riverbank back up the valley to relieve the horizontal blanket.

A 5- by 3-foot drain was installed on the upstream side to relieve several springs and seepage areas before embankment work began. The drain exists upstream of the toe of the waste berm in the lake area. No pervious material was placed closer than 125 feet to the centerline.

7. Instrumentation.

a. General. Instrumentation at William H. Harsha Lake, Ohio, consists of open system piezometers, 5 observation wells, 6 settlement plates, and 44 movement markers to monitor the behavior of both the main dam and the Saddle Dam. The locations of the instrumentation are shown on Plates 47 through 51.

b. Piezometers. (Plates 72 through 92)

(1) Main Dam. A total of 23 operational piezometers are installed in the dam. All are of the open system type. The embankment has 18 peizometers, 2 upstream and 16 downstream of the centerline. Of the 18 embankment peizometers, 5 are located in the horizontal blanket The foundation has 5 downstream piezometers. The piezometers indicate seepage from the abutments which is testified to by OW1 on the right abutment ridge and OW-5 on the left abutment which follows pool changes. The abutments consist of shale with limestone beds that apparently permit water to seep in a horizontal plane. It appears that the downstream section of the dam is affected by this abutment seepage. The downstream peizometers react with a decreasing amount approximately proportional to the distance from centerline. This is probably from saturated condition and nearly direct connection between the pool and horizontal blanket through the limestone layers in the abutment. See Plate 48 for apparent phreatic water surface elevations throughout the embankment. Piezometers have shown significant amounts of water present in the downstream shell indicating the ineffectiveness of the drains. Remedial measures were taken to reduce entry of water into the downstream shell (horizontal abutment drains) and to provide controlled drainage out of the downstream shell (trench drains into the dam). The water levels in the downstream shell are generally dropping; therefore, at or near normal pool levels seepage through and/or around the dam, must be less than the total flow out of the horizontal blanket.

The dam was originally designed assuming an effective, inclined and horizontal drainage system. Subsequent stability analyses assuming an ineffective drainage system also show the dam to be stable.

(2) Saddle Dam. There are 14 operational piezometers installed in the saddle dam. All are of the open system type. The embankment has 3 downstream piezometers. The foundation has 5 upstream piezometers and 6 downstream piezometers. The upstream foundation piezometers are relatively steady. The downstream piezometers are relatively steady. One of these piezometers is dry. The downstream embankment piezometers are dry. See Plate 50 for apparent phreatic water surface elevations throughout the embankment.

(3) Observation Wells. The five observation wells located in the right abutment were installed to monitor the area between the dam and the saddle dam. A single line grout curtain extends from the right abutment of the dam 1,000 feet towards the saddle dam. This grout curtain extends 60 feet into rock. OW-1 is located on the right abument downstream of the grout curtain and follows the pool closely, indicating a seepage path exists between the pool and this area. OW-1 extends well below the grout curtain. OW-7 is also located on the right abutment downstream of the grout curtain. The readings above pool levels combined with the rise and fall in the general time frame as the pool indicates the primary reaction of OW-7 is to surface water. OW-2 is maintaining essentially steady readings and does not appear to be affected by changes in pool level. OW-4 follows the pool closely, though at a level which indicates a head loss through this area. This shows the seepage which is possible through the shale with interbedded limestone abutment. OW-3 has had a high water surface elevation even before impoundment was begun. It has shown a very slow but steady decline in water surface elevation throughout the years and has not apparently been affected by the pool, apparently affected by surface ground water.

c. Movement Markets. Locations of movement markers are shown on Plates 47 and 49, with typical movement plots on Plates 52 through 65. The rows at the upstream and downstream berms were installed in November 1974. The other rows were installed in November 1976. The movement monuments were reconditioned in late 1981. Some monuments were reset, some were reestablished and reference elevations and offsets were taken.

(1) Main Dam. Row 1 on the upstream slope at approximate elevation 675 was inundated in March 1978, and no further readings have been taken. No significant consistent horizontal movement has been measured on the main dam. Vertically, the largest settlements are occurring both along the deepest portions of the former valley and in proportion to the embankment height. Thus all settlements are fairly gradual with no apparent differential settlement.

(2) Saddle Dam. To date the movement markets on the saddle dam have shown no significant, consistent horizontal movement. The amount of vertical movement is not considered significant.

d. Settlement Plates. Instrumentation plan for the settlement plates is shown on Plate 49. The six settlement plates were installed on original ground as embankment work started. Design calculations predicted total settlement in excess of thirty inches due to the weak foundation material. The maximum settlement to date has been in the order of eighteen inches.

8. Construction Modifications.

a. Revised Sand Drain Gradation. During the first stages of construction, the contractor experienced difficulties meeting the No. 100 screen requirements of 0 - 3% by weight passing. Most of the production was running 3 - 5% passing the No. 100 screen. Subsequent tests by the Corps determined that a maximum of 5% passing the No. 100 screen would provide satisfactory drainage. The contract was modified to provide for a gradation change of 0 - 5% by weight passing the No. 100 sieve. No further significant gradation problems with the filter drain material was encountered during the remainder of the project.

b. Delete Upstream Graded Aggregate (Dam). The dam contract plans and specifications called for a 5-foot wide graded aggregate transition zone between the impervious core and the upstream random rock zone. This transition material was graded from 2 inches down to the No. 200 sieve. During blasting and excavation procedures in the spillway, it was discovered there was a considerable amount of thinly bedded limestone and finely broken shale. The contractor submitted a Value Engineering proposal to use this material in the random rock zone adjacent to the impervious core on a selective basis in lieu of the required transition material. Engineering studies determined that this was feasible. The contract was changed to allow use of this spillway material. No significant problems were encountered and a very fine shaley transition zone was maintained during construction between the impervious core and upstream random rock zones.

c. Stage III Permanent Cofferdam. During construction of the third stage permanent cofferdam (random earth fill) in the fall of 1974, two things became apparent. The first problem was trying to reach the required protection height late in the construction season with an earthfill that had moisture control. Several important days were being lost due to light rain. The second problem was a balance of materials from the spillway excavation. The farther the project progressed, the more it became certain that an excess quantity of random rockfill material existed and that impervious earth material would run close. With these two problems in mind, Engineering and Construction Divisions decided to switch to random rock on the 3rd stage cofferdam at ± elevation 675. This is shown on the dam field control test location cross-sections Stations 104+00 through 110+00 and as-built drawings.

d. Saddle Dam, Downstream, Waste Berm. Construction sequence on the saddle dam called for embankment to elevation 750 during 1973 and then no additional embankment until 1975 to allow for settlement. However, in view of favorable settlement records during 1973 and the spring of 1974, and the need for a sequence of spillway excavation (needed to uncover more rock in the spillway excavation for dam embankment), the contractor was permitted to continue embankment at a controlled rate on the saddle dam in 1974. As an added safety measure and in view of the overall waste material available, it was decided by Engineering Division to raise the downstream waste berm on the saddle dam from elevation 733 to 745. This is noted on the as-built drawings.

9. Diversion and Closure.

The inlet channel and the major portion of retreat channel were excavated during the 1974 construction season. The stream was diverted through the outlet works on 12 August 1974. First stage permanent cofferdam work started on 17 August 1974. The first stage permanent cofferdam was overtopped by flooding on 30 August 1974 (Cofferdam ±50 feet high). The river was rediverted and work began again on the first stage permanent cofferdam on 6 September 1974. The first stage permanent cofferdam was finished on 20 September 1974. The second stage permanent cofferdam was finished to elevation 715 on 22 October 1974. The third stage permanent cofferdam was to the required winter protection height of elevation 737 on 26 November 1974. The remainder of retreat channel work was completed in fall season of 1975.

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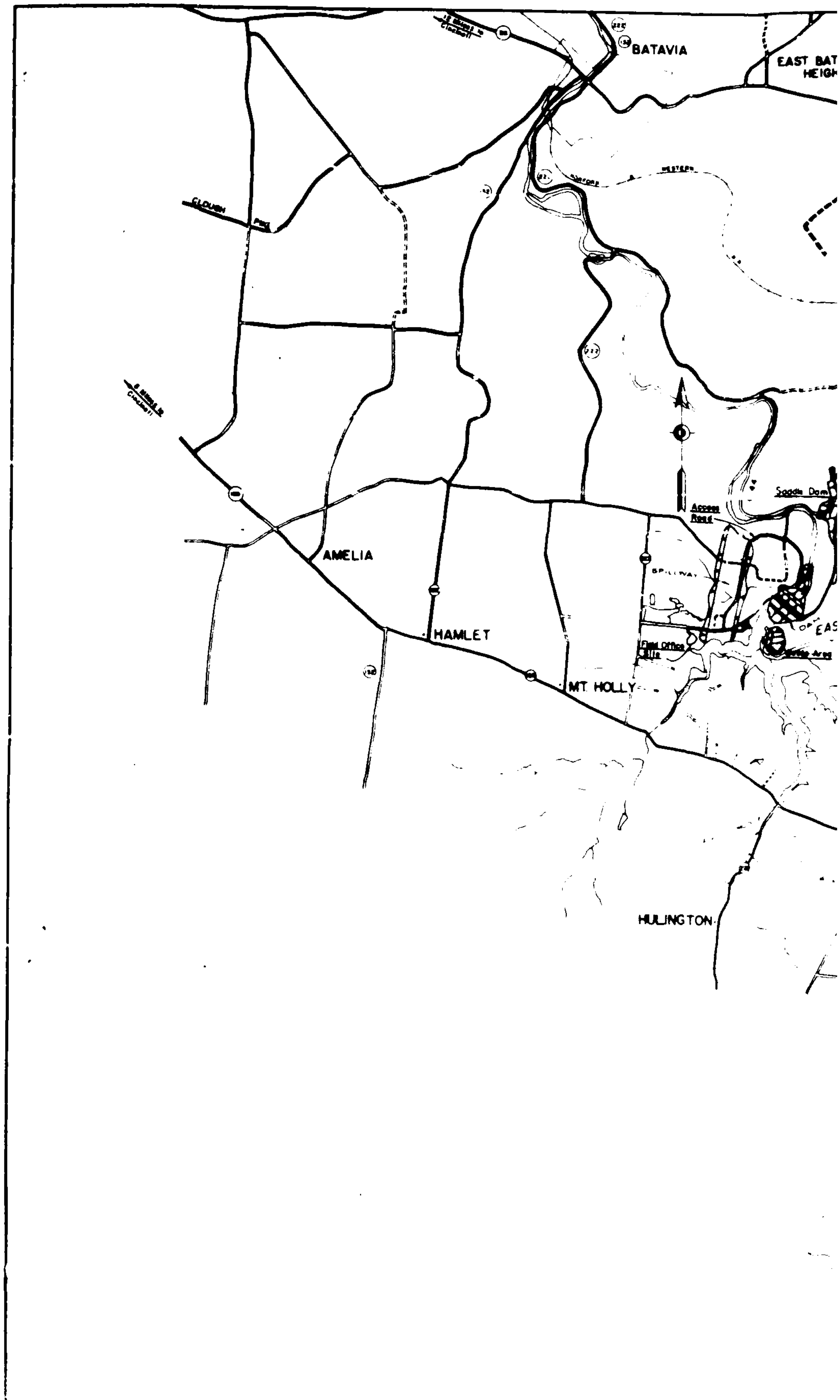
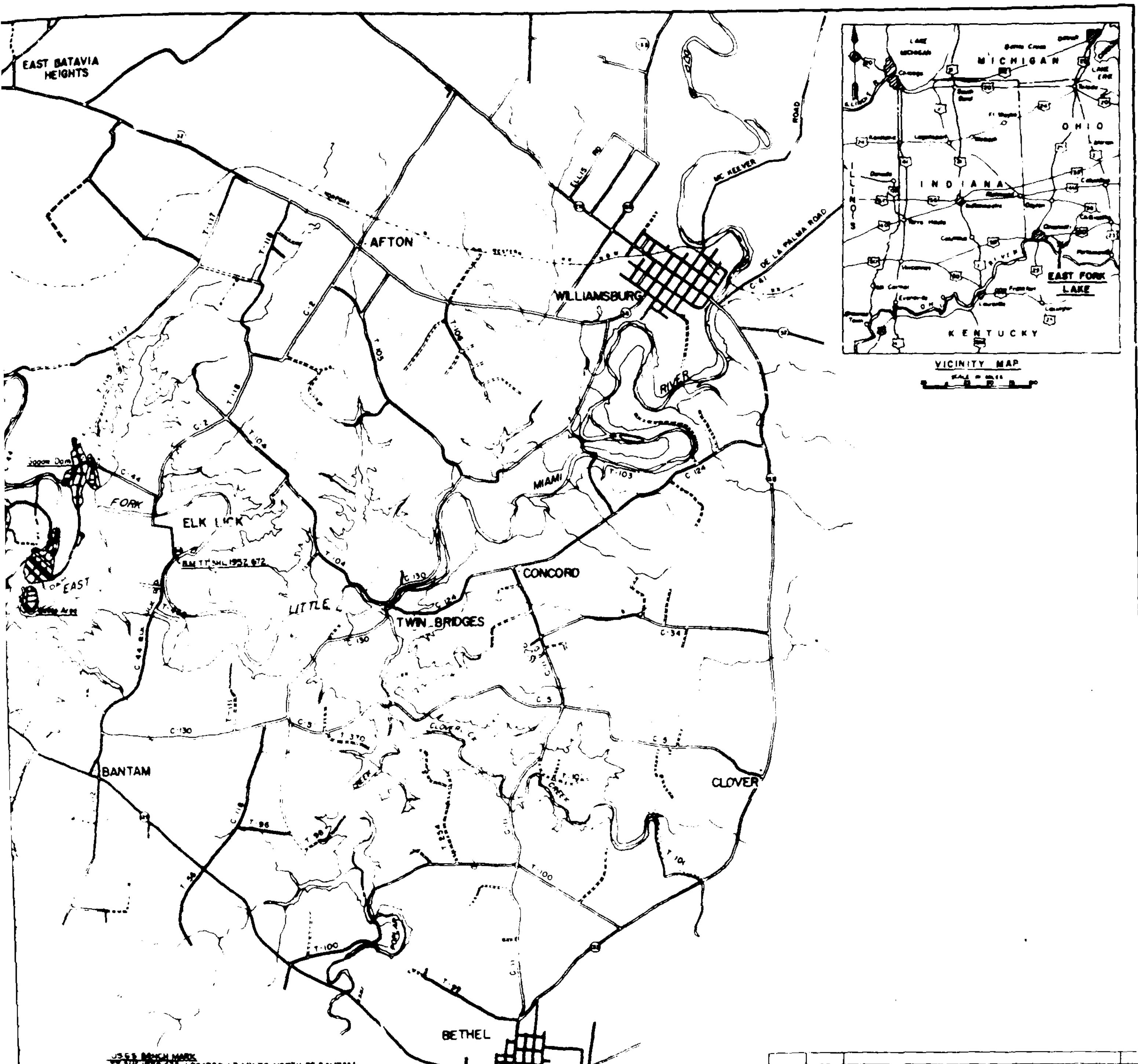




USGS BENCH MARK
TT SHL 1952 672 LOCATED 1.8 MILES NORTH OF BANTAM ALONG ELK LICK ROAD (C-44), 30 FT. S. OF FENCE & FIELDLINE W., 29 FT. EAST OF ℄ OF ROAD AT CURVE, 12 FT. W. OF RIM OF BLUFF OVERLOOKING E. FORK OF LITTLE MIAMI RIVER ABOUT LEVEL WITH ROAD AT BEND, IN GRASSY PLOT, STANDARD TABLET STAMPED TT SHL 1952 672.
EL. 672.410

NOTE
ADDITIONAL BENCHMARKS ARE SHOWN ON INDIVIDUAL SITE PLANS

REVISION	DATE	DESCRIPTION	BY

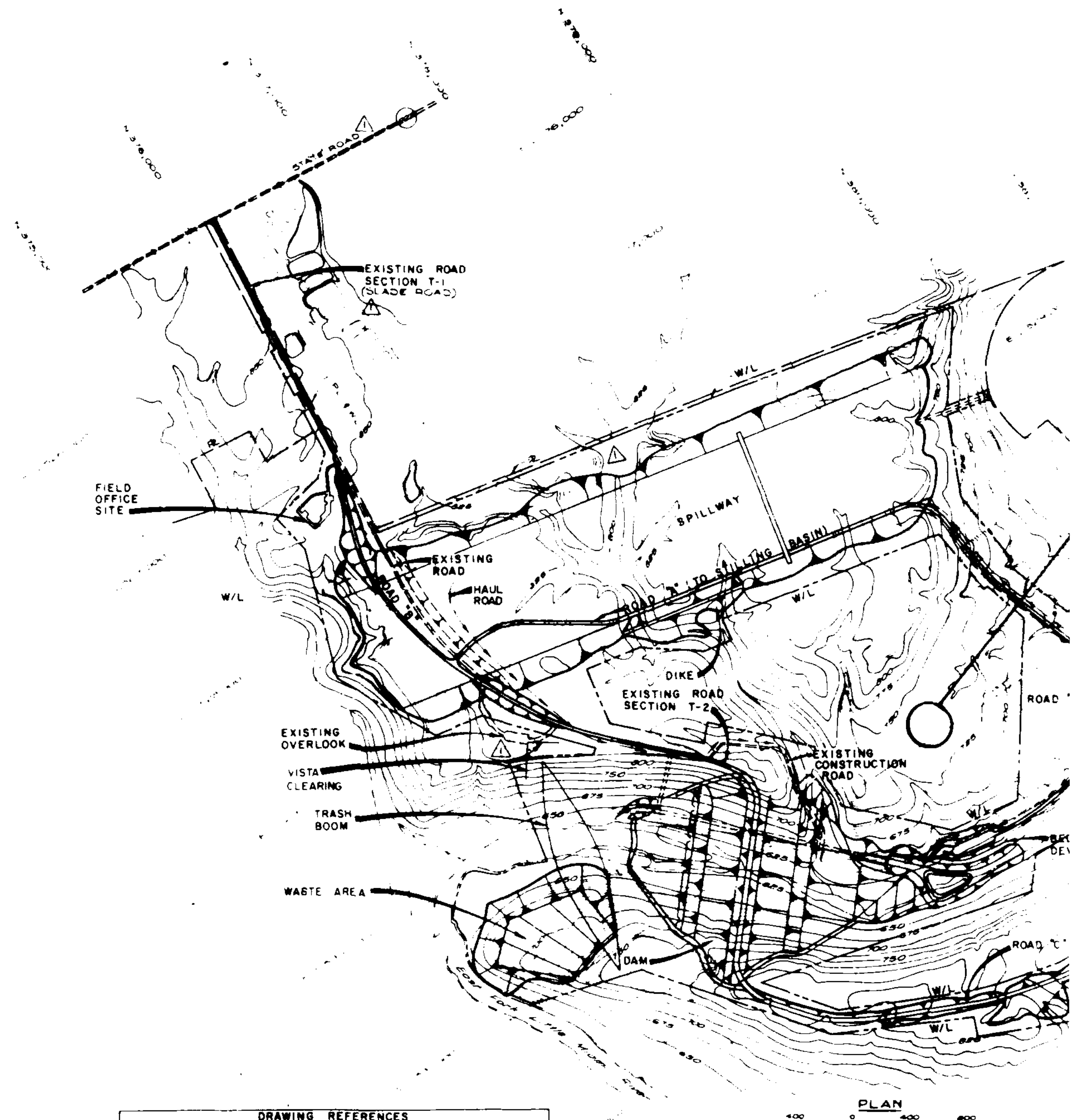
U.S. ARMY ENGINEER DISTRICT, LOUISVILLE
CORPS OF ENGINEERS
LOUISVILLE, KENTUCKY

DESIGNED BY: LED
DRAWN BY:
TRACED BY:
CHECKED BY:
SUBMITTED:
APPROVED:

OHIO RIVER BASIN
EAST FORK LAKE
EAST FORK LITTLE MIAMI RIVER

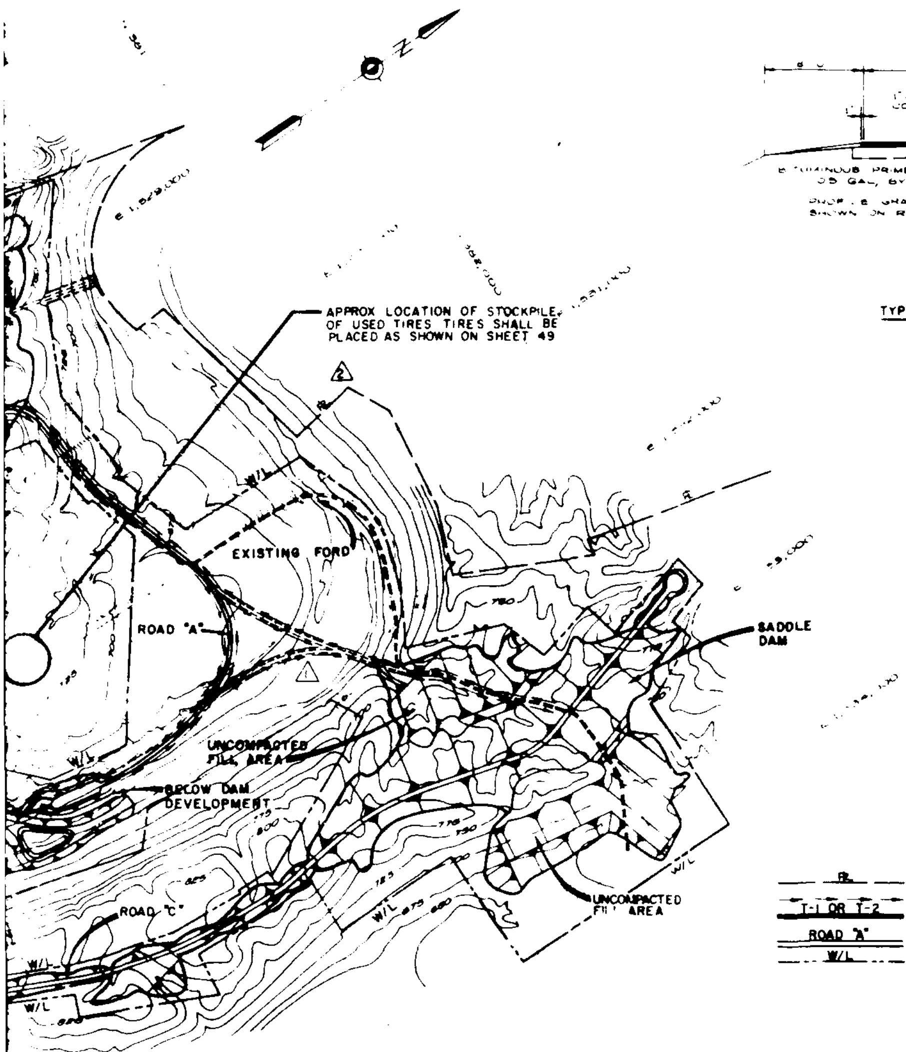
LAKE AREA MAP

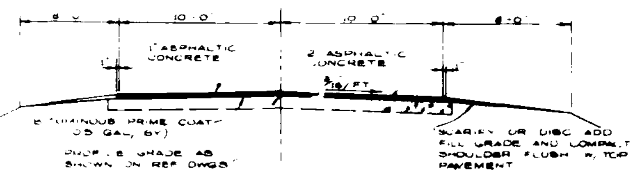
CORPS OF ENGINEERS



DRAWING REFERENCES	
DESCRIPTION	SHEET NO.
SEQUENCE OF CONSTRUCTION PLAN	[illegible]
DAM SITE PLAN	
SADDLE DAM SITE PLAN	
SPILLWAY SITE PLAN	
ROAD A TO BELOW DAM AREA	[illegible]
ROAD B TO DAM	[illegible]
ROAD C TO SADDLE DAM	[illegible]
EXISTING ACCESS ROAD TOPPING DETAILS OVER SECTIONS T1 AND T2	[illegible]
BELOW DAM DEVELOPMENT	[illegible]
FIELD OFFICE SITE PLAN	[illegible]

U. S. ARMY





* EXISTING BASE SHALL BE SCARIFIED AND BROUGHT TO PROFILE GRADE SHOWN ON ATTACHED REFERENCE DWGS LM 21-12.1/78 THRU 82 AND 80 BASE MATERIAL SHALL BE ADDED AS REQUIRED PAVEMENT SHALL BE PLACED ON BASE AS SHOWN

TYPICAL SECTION ROAD T-1 AND T-2
NO SCALE

LEGEND

PL	GOVERNMENT PROPERTY LINE
T-1 OR T-2	HAUL ROAD LOCATION AND DIRECTION OF TRAFFIC FLOW
	EXISTING ACCESS ROAD TO BE TOPPED UNDER THIS CONTRACT
ROAD "A"	NEW ROADS UNDER THIS CONTRACT
W/L	CONTRACTORS WORKING LIMITS

GENERAL NOTES

1. FIELD OFFICE SITE SHALL BE THE FIRST ITEM OF CONSTRUCTION ROADS AND PARKING AREAS AT FIELD OFFICE SITE, INCLUDING CONNECTION TO EXISTING SLADE ROAD, SHALL BE CONSTRUCTED COMPLETE AT ONE TIME (INCLUDING SURFACE COURSES)
2. EXISTING ACCESS ROAD FROM ITS JUNCTION WITH STATE ROAD 222 OVER TO THE EAST ENTRANCE OF THE EXISTING OVERLOOK SHALL BE KEPT OPEN TO THE PUBLIC DURING EARLY STAGES OF CONSTRUCTION SEE SEQUENCE OF CONSTRUCTION DRAWING FOR FURTHER DETAILS
3. HAUL ROADS SHOWN BRANCHING NORTH FROM ROAD A MAY BE LOCATED ANYWHERE WITHIN WORKING LIMITS SHOWN THE EXISTING CONSTRUCTION ROAD @ THE LEFT END OF THE DAM AND ALL HAUL ROADS (EXCEPT THOSE LOCATED ON THE ALIGNMENT OF PERMANENT PLANNED ROADS "A" OR "B") SHALL BE DEGRADED COMPLETELY HAUL ROADS LOCATED ON THE ALIGNMENT OF PLANNED PERMANENT ROADS "A" OR "B" SHALL BE DEGRADED ONLY TO THE EXTENT NECESSARY TO MEET FINAL PLANNED PROFILE GRADES, TO MAINTAIN PLANNED CENTERLINE OF PAVEMENT, TO HOLD THE PLANNED WIDTH OF PAVEMENT AND TO DRAIN SHOULDERS.
4. SURFACE COURSES ON ROADS A, B, C AND ON REACHES T-1 & T-2 OF EXISTING ROAD SHALL BE THE LAST ITEM OF CONSTRUCTION ON THE PROJECT EXCEPT THAT AT THE START OF CONSTRUCTION THE CONTRACTOR SHALL SEAL AND CHIP THE EXISTING SLADE ROAD FROM ITS JUNCTION WITH S.R. 222 TO STA 64+50
5. THE UNCOMPACTED FILL AREA DOWNSTREAM OF THE SADDLE DAM AND UPSTREAM OF THE SADDLE DAM BETWEEN STATIONS 21+30 AND 26+00 SHALL BE PLATED TO THE GRADE INDICATED IN THE PLANS
6. EXCAVATION OF THE SPILLWAY SHALL START NEAR THE CENTER OF ITS LENGTH IN ORDER TO UNCOVER ROCK EARLY FOR USE IN CONSTRUCTING THE PERMANENT COFFERDAM
7. ... WATER LINES ... PROJECT AREA WILL BE RELOCATED BY OTHERS
8. COMPACTED BACKFILL IS REQUIRED ALONG SIDES ... OF EXISTING CONDUIT SEE DETAIL ON SHEET ...

REVISION	DATE	DESCRIPTION	BY
2	5 AUG	ADDED LOCATION OF STOCKPILE OF TIRES (CONT MOD)	JES
1	DEC 72	GENERAL NOTES CHANGED & ADDED, ... ROADS CHANGED & VISTA CLEARING CHANGED SPILLWAY ... (MOD NO. 1)	CLL

U. S. ARMY ENGINEER DISTRICT, LOUISVILLE
CORPS OF ENGINEERS
LOUISVILLE, KENTUCKY

DESIGNED
DRAWN JEN TRACED JEN
CHECKED
SUBMITTED [signature]
APPROVAL RECD
ASST CHIEF ENGINEERING DIV
APPROVED
CHIEF ENGINEERING DIVISION

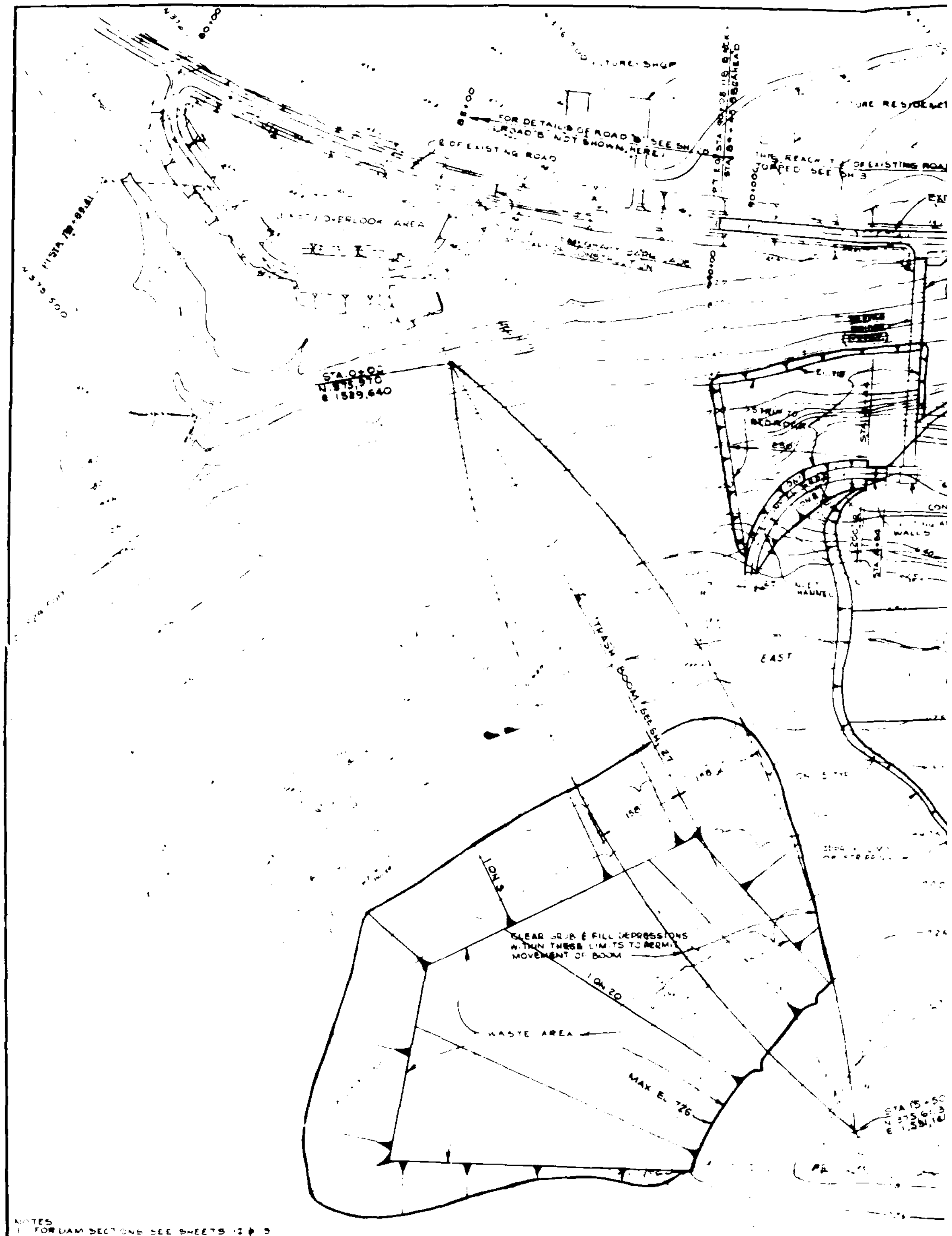
OHIO RIVER BASIN
EAST FORK LAKE
EAST FORK LITTLE MIAMI RIVER

GENERAL PLAN

APPROVED
COL. CORPS OF ENGINEERS DISTRICT ENGINEER
DATE OCTOBER 1972
SCALE
DRAWING NUMBER
LM 21-123/3

Plate 2 EXHIBIT [redacted]

CORPS OF ENGINEERS



NOTES

1. FOR DAM SECTIONS SEE SHEETS 12 & 9
2. FOR DETAILED PLAN OF BELOW-DAM DEVELOPMENT ADJACENT TO STILLING BASIN SEE SHEETS 49 THRU 53
3. FOR PAVED GUTTER DETAILS SEE SHEET 47 & STD CONSTRUCTION DWG MC5 OF THE OH DISTRICT OF HWYS.
4. ELEVATIONS SHOWN THUS $\boxed{680}$ ARE FINISHED GRADE ELEVATIONS
5. FOR SECTION A-A SEE SHEET 2
6. HAUL ROUTE LOCATIONS AND DIRECTIONS ARE SHOWN ON SHEET 3
7. FOR TRASH BOOM DETAILS SEE SHEET 27
8. FOR GENERAL NOTES APPLYING TO ROAD 'B' SEE SH 28
9. THE GENERAL PUBLIC SHALL BE PREVENTED FROM ENTERING THE CONSTRUCTION AREA BY A TEMPORARY BARRICADE INSTALLED ADJACENT TO OVERLOOK. SEE ABOVE FOR LOCATION.
10. FOR ADDITIONAL DETAILS OF RETREAT CHANNEL BELOW OUTLET WORKS, SEE "RETREAT CHANNEL 1912" SH LM 21-12 1/68

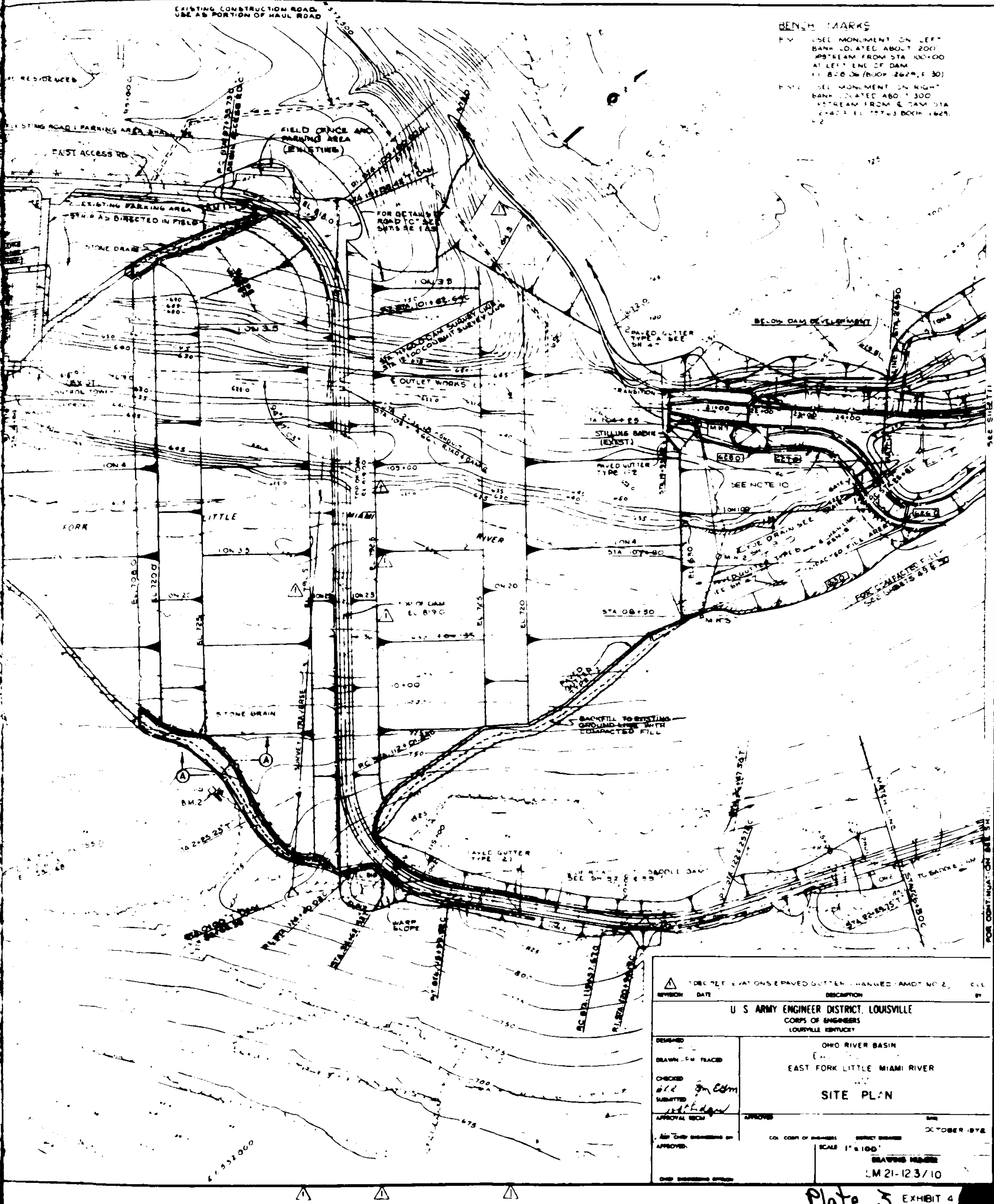
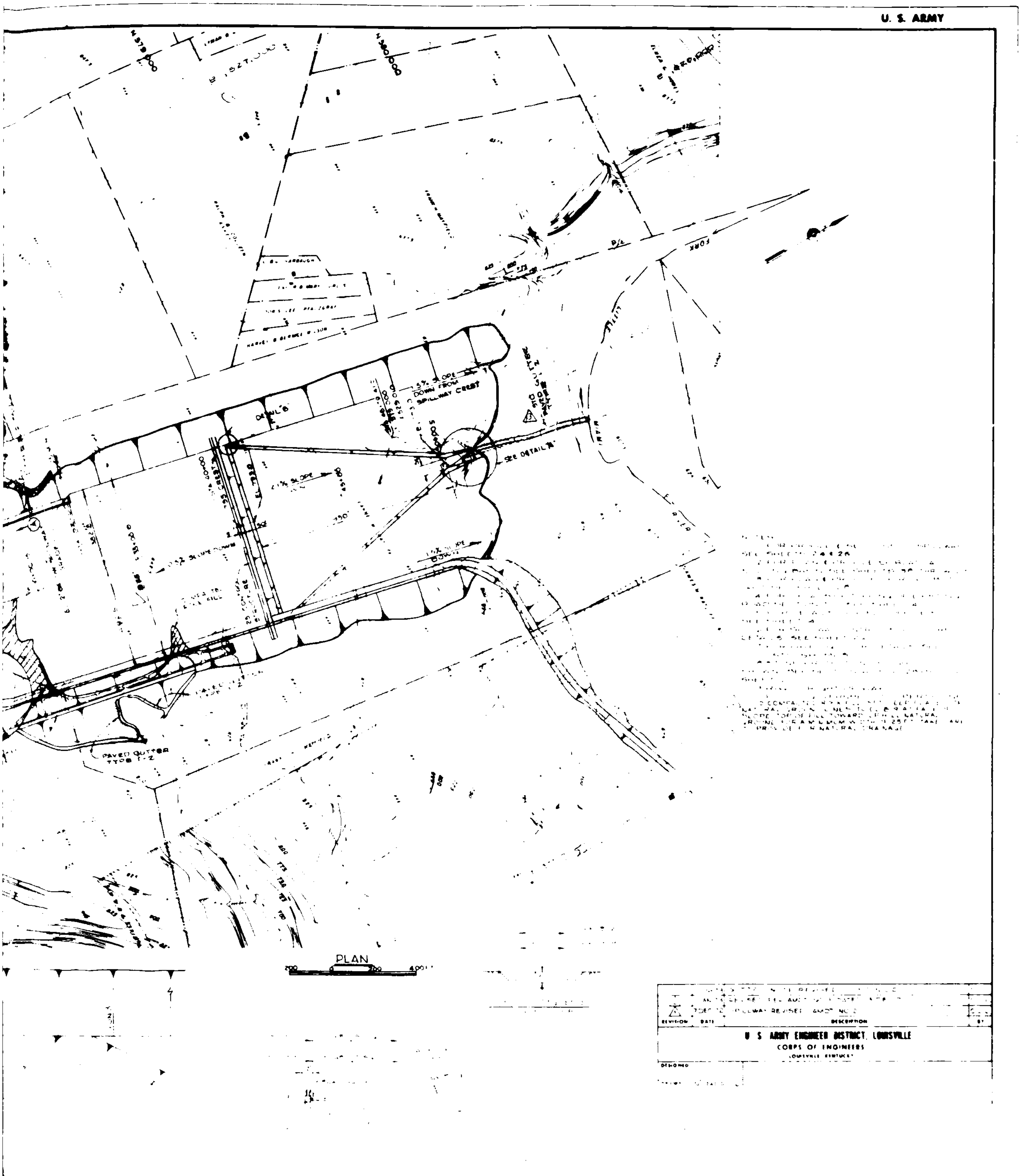
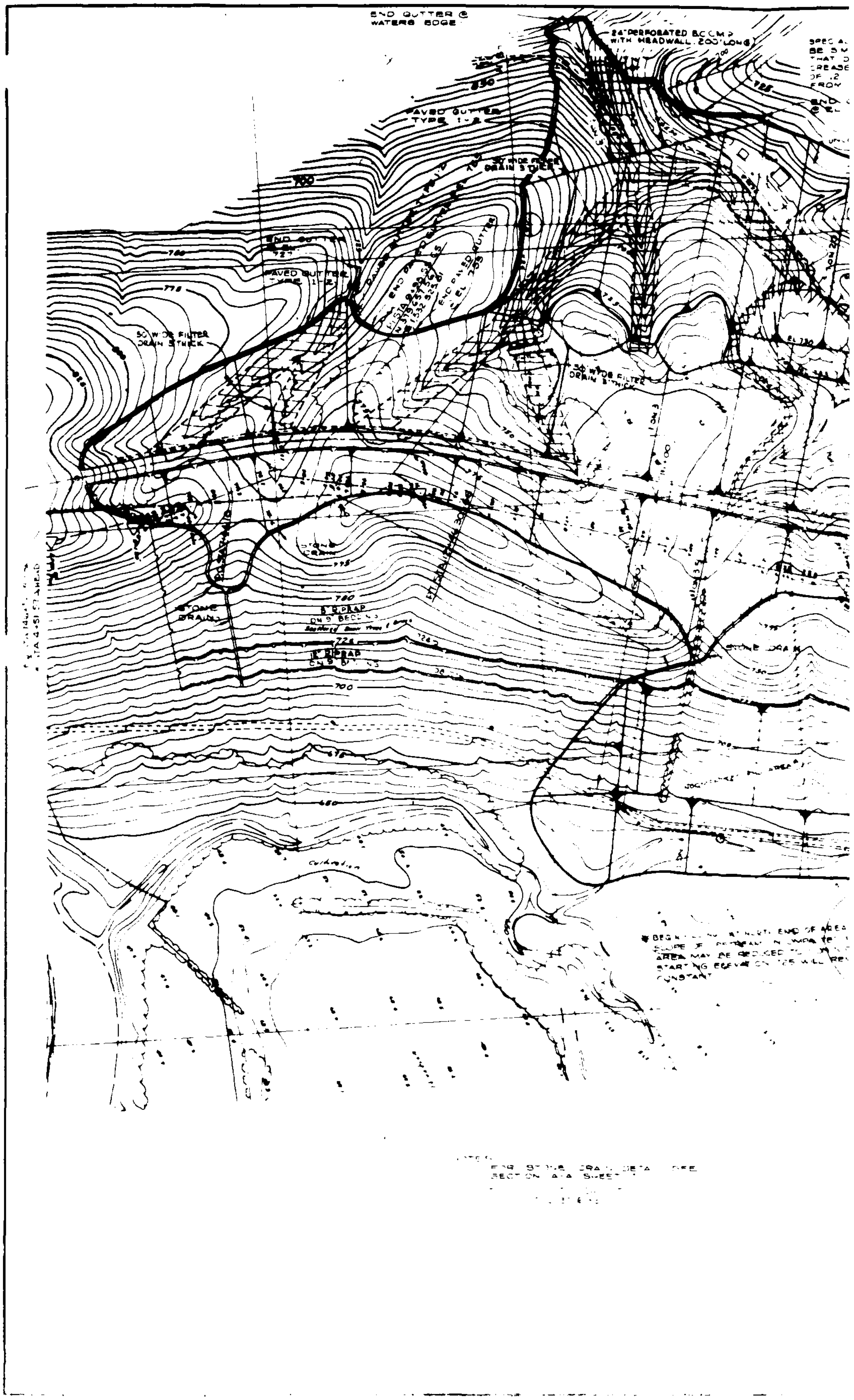
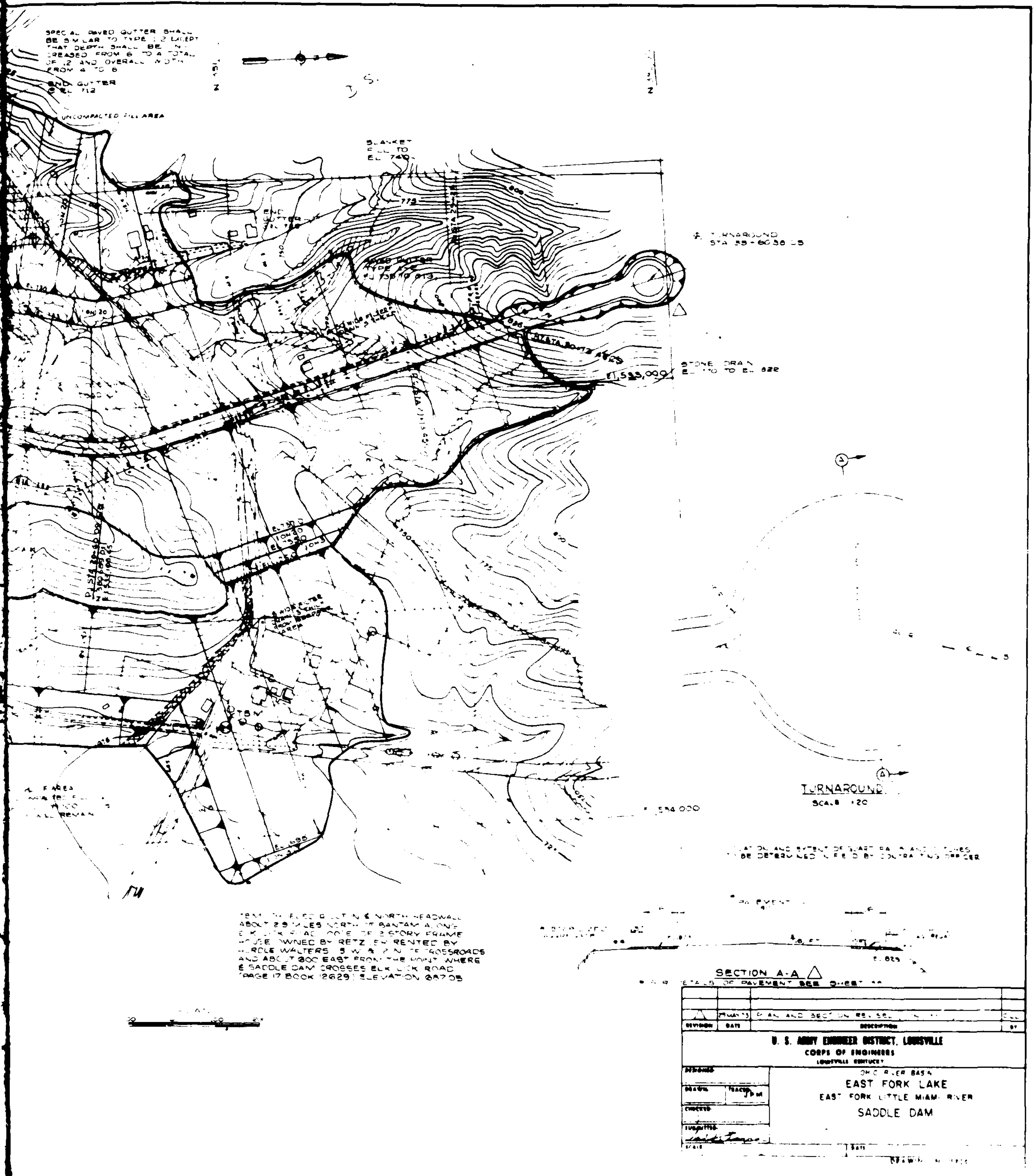


Plate 3 EXHIBIT 4

CORPS OF ENGINEERS

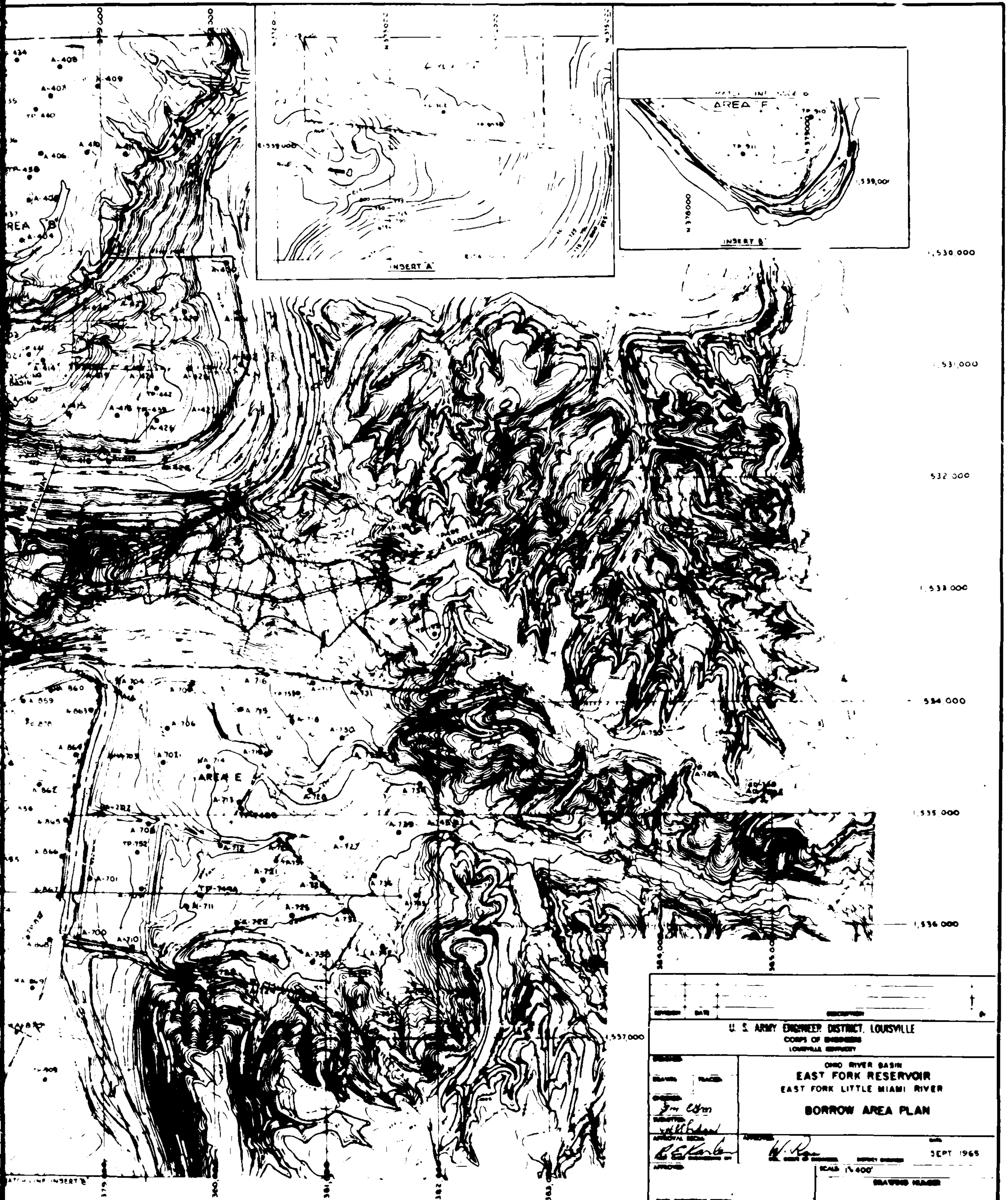

U. S. ARMY
SPILLWAY CREST
SEE DETAIL
PAVED GUTTER
FORK
PLAN
U. S. ARMY ENGINEER DISTRICT, LOUISVILLE
CORPS OF ENGINEERS
LOUISVILLE, KENTUCKY

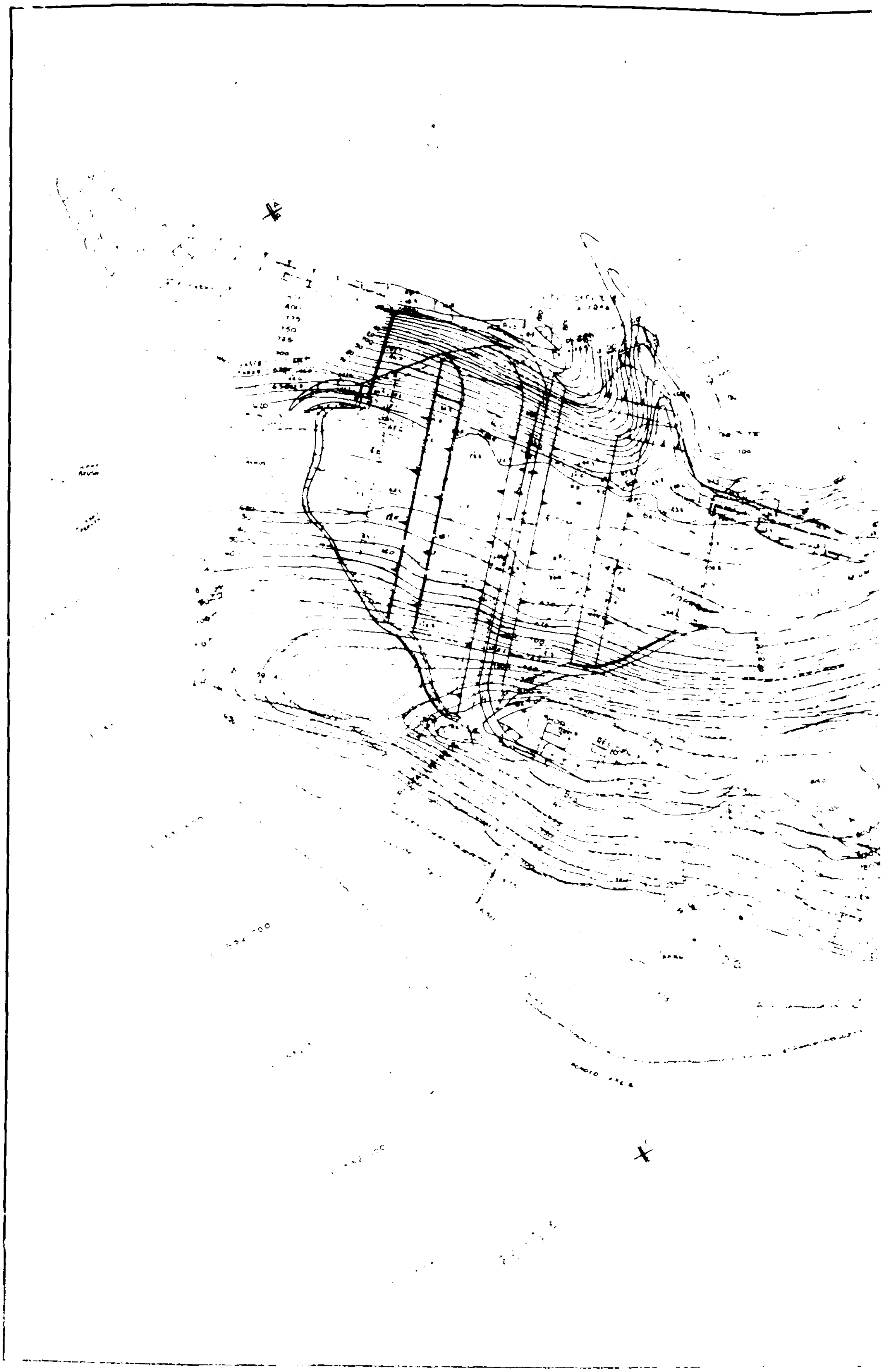

END GUTTER @
WATERS EDGE
24" PERFORATED B.C.C.M.P.
WITH HEADWALL, 200' LONG
PAVED GUTTER
TYPE 1-A
50' WIDE FILTER
DRAIN 3' THICK
50' WIDE FILTER
DRAIN 3' THICK
STONE
DRAIN
STONE DRAIN
700
760
775

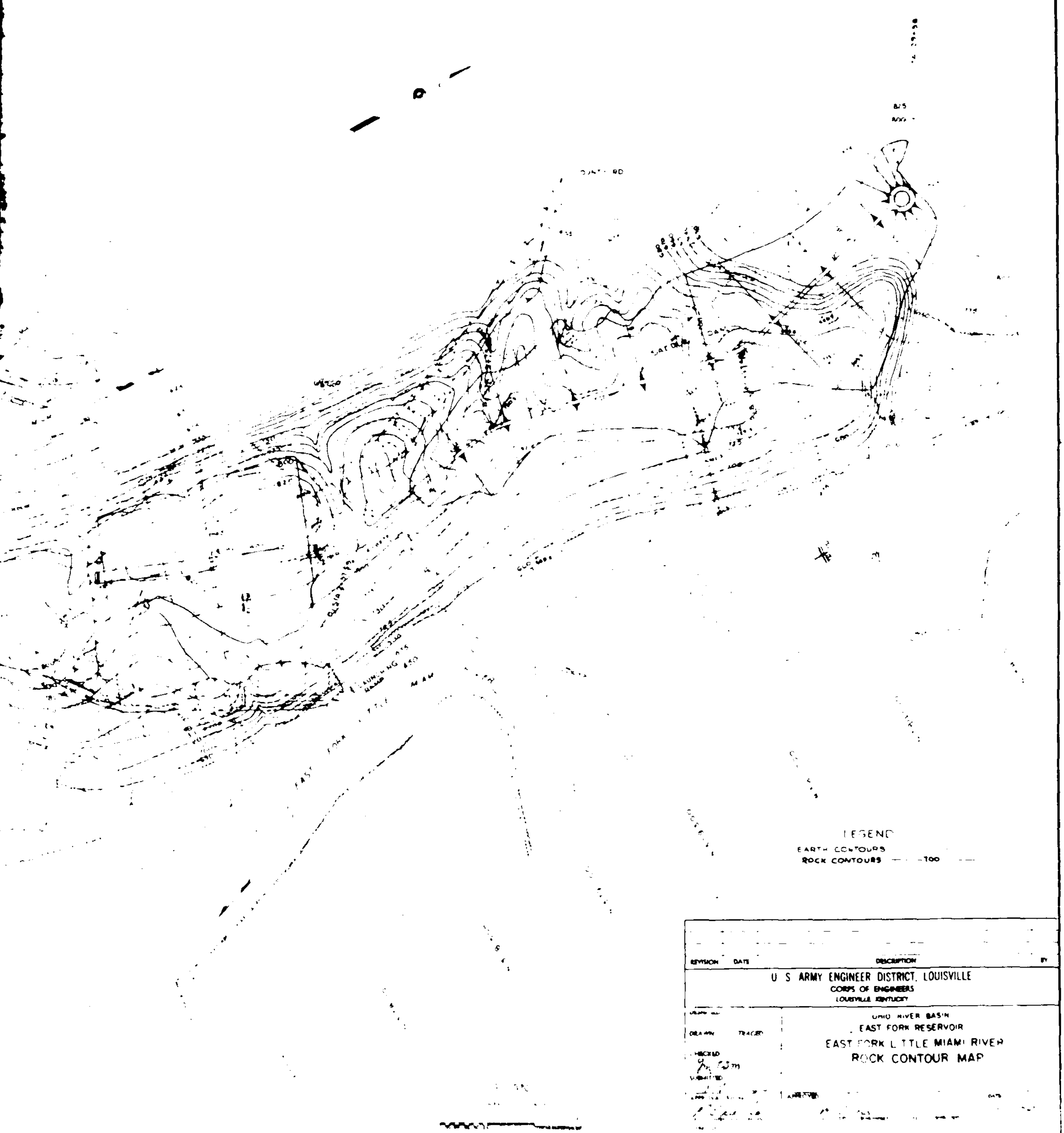


SPECIAL PAVED GUTTER SHALL BE SIMILAR TO TYPE 2 EXCEPT THAT DEPTH SHALL BE INCREASED FROM 6 TO A TOTAL OF 12 AND OVERALL WIDTH FROM 4 TO 6
END GUTTER EL 712
UNCOMPACTED FILL AREA
BLANKET FILL TO EL 740
END GUTTER
PAVED GUTTER TYPE
TURNAROUND STA 55+60.36
STONE DRAIN
E 1,533,000
E 1,534,000
TBM
TURNAROUND
SCALE 1"=20'
SECTION A-A
ABOUT 2.9 MILES NORTH OF BANTAM ALONG
2 STORY FRAME
OWNED BY RETZ
RENTED BY
WALTERS
CROSSROADS
AND ABOUT 800 EAST FROM THE POINT WHERE
SADDLE DAM CROSSES ELK LICK ROAD
PAGE 17 BOOK 2629 ELEVATION 687.05
PAVEMENT
REVISION
DATE
DESCRIPTION
BY
U. S. ARMY ENGINEER DISTRICT, LOUISVILLE
CORPS OF ENGINEERS
LOUISVILLE KENTUCKY
DESIGNED
DRAWN
TRACED J P M
CHECKED
SUBMITTED
SCALE
DATE
EAST FORK LAKE
EAST FORK LITTLE MIAMI RIVER
SADDLE DAM

AREA "C"
AREA "B"
CONTROL TOWER
AREA G
MATCH LINE
376,000
1,529,000
1,530,000
1,535,000
1,536,000


INSERT A
INSERT B
AREA F
AREA B
AREA E
SADDLE DAM
1,530,000
1,531,000
532,000
1,533,000
534,000
1,535,000
1,536,000
1,537,000
MATCH LINE INSERT B
U. S. ARMY ENGINEER DISTRICT, LOUISVILLE
CORPS OF ENGINEERS
LOUISVILLE, KENTUCKY
OHIO RIVER BASIN
EAST FORK RESERVOIR
EAST FORK LITTLE MIAMI RIVER
BORROW AREA PLAN
SEPT 1965
SCALE 1"=400'
DRAWING NUMBER



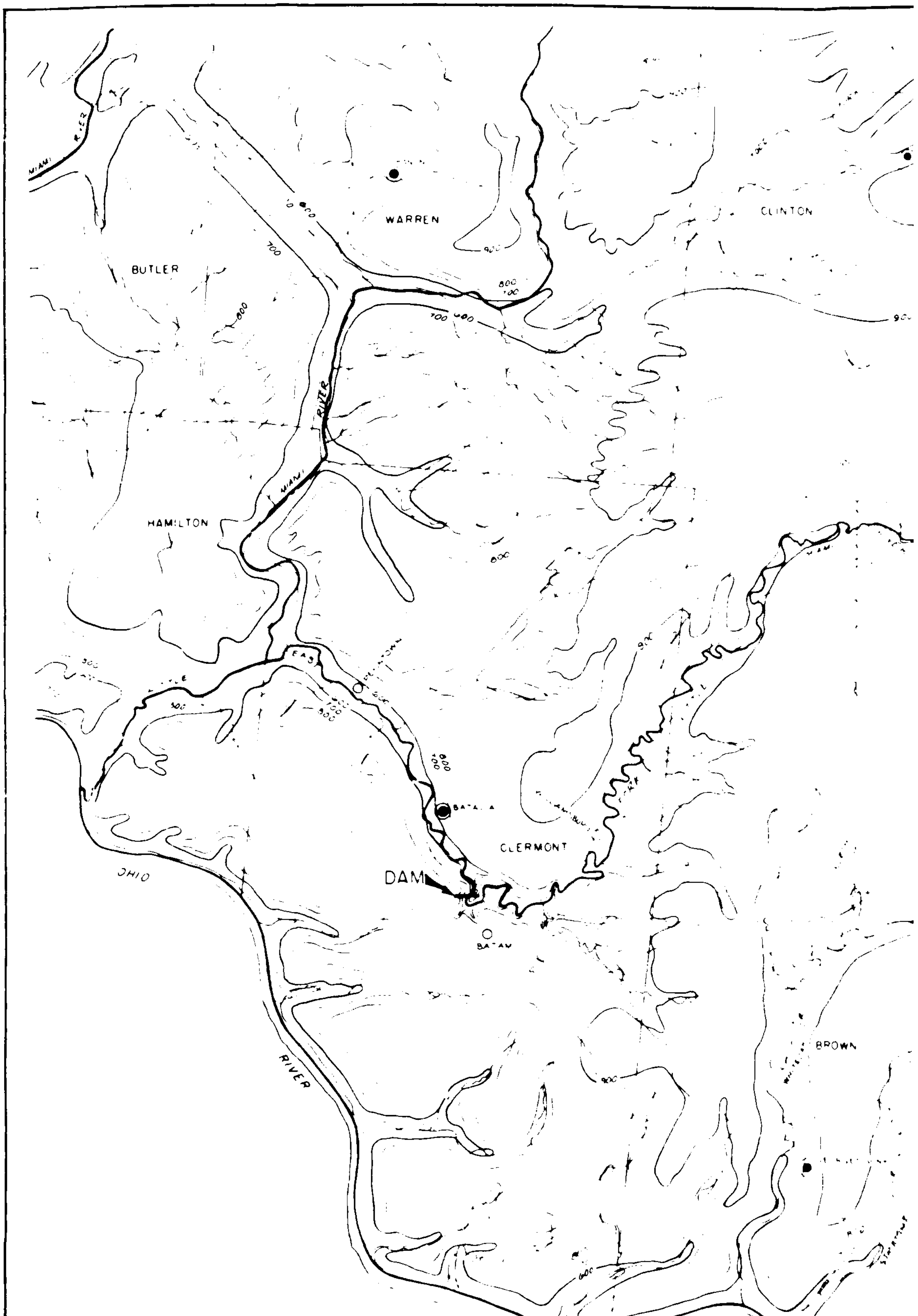


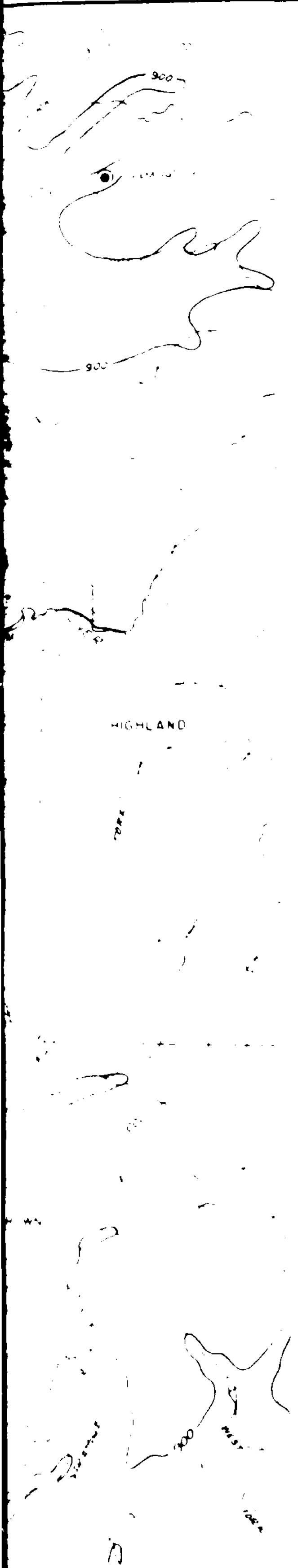
REVISION	DATE	DESCRIPTION	BY

U. S. ARMY ENGINEER DISTRICT, LOUISVILLE
CORPS OF ENGINEERS
LOUISVILLE, KENTUCKY

DRAWN TRACED
CHECKED
SUBMITTED
APPROVED DATE

OHIO RIVER BASIN
EAST FORK RESERVOIR
EAST FORK LITTLE MIAMI RIVER
ROCK CONTOUR MAP


WARREN
CLINTON
BUTLER
HAMILTON
CLERMONT
BROWN
MIAMI RIVER
MIAMI RIVER
OHIO RIVER
DAM
PLAN



NOTES

MAP REPROD ... IN PART FROM ... REPORT ...
PROBABLE ... BEDROCK ... THE ... ATED
AREA IN OHIO" BY JAMES ... 959

2 SOURCE OF DATA OHIO DIVISION OF WATER, OHIO GEOLOGICAL SURVEY, AND U S GEOLOGICAL SURVEY GROUND WATER DIVISION

BEDROCK ... OF EAST FORK DAM REVISED ON BASIS OF BEDROCK DATA OBTAINED SUBSEQUENT TO 959

LEGEND

APPROXIMATE ... ON THE BEDROCK SURFACE ELEVATIONS ARE IN FEET ABOVE MEAN SEA LEVEL EVERY THIRD CONTOUR ... ATED CONTOUR INTERVAL ... 00 FEET

PRE ... DRAINAGE

... NES

REVISION	DATE	DESCRIPTION	BY

U S ARMY ENGINEER DISTRICT LOUISVILLE
CORPS OF ENGINEERS
LOUISVILLE KENTUCKY

DESIGNED

DRAWN TRACED

CHECKED B K

SUBMITTED

OHIO RIVER BASIN
EAST FORK RESERVOIR
EAST FORK LITTLE MIAMI RIVER

PREGLACIAL DRAINAGE MAP

APPROVAL RECM

ASST CHIEF ENGINEERING DIV

APPROVED DATE

COL CORPS OF ENGINEERS DISTRICT ENGINEER

APPROVED

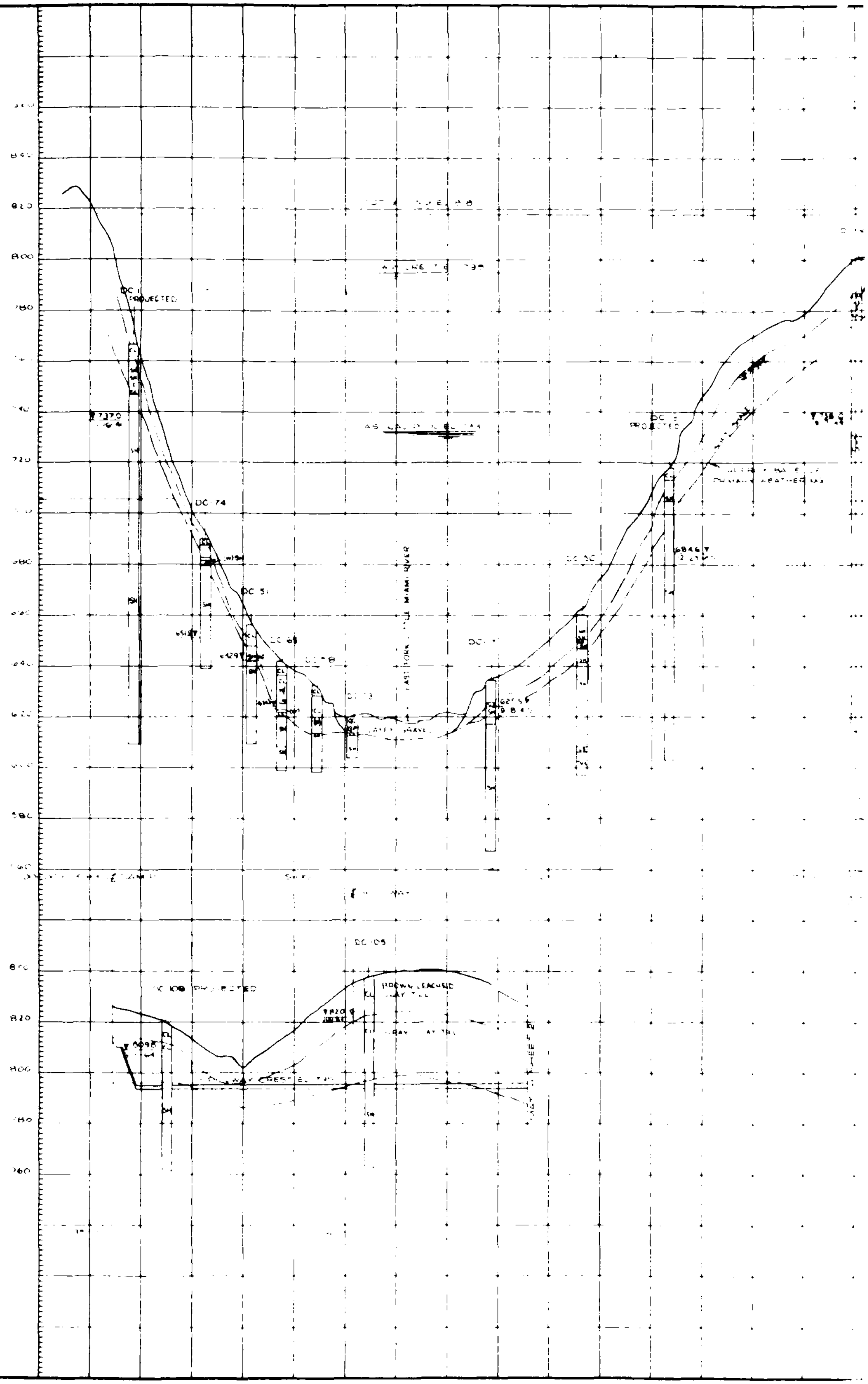
CHIEF ENGINEERING DIVISION

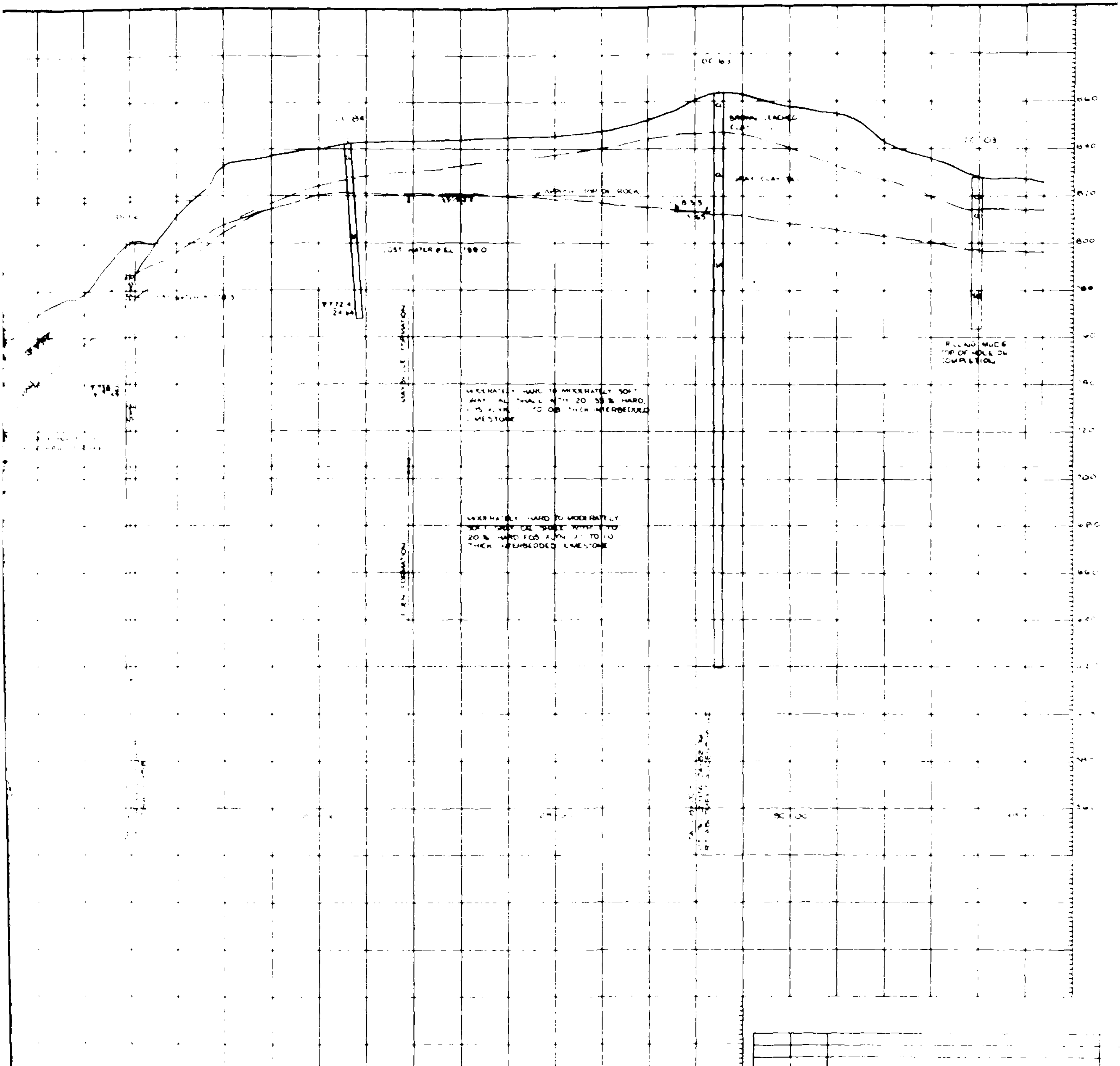
SCALE MILES

DRAWING NUMBER

[redacted]

CORPS OF ENGINEERS





REVISION	DATE	DESCRIPTION	BY

U.S. ARMY ENGINEER DISTRICT, LOUISVILLE
CORPS OF ENGINEERS
LOUISVILLE KENTUCKY

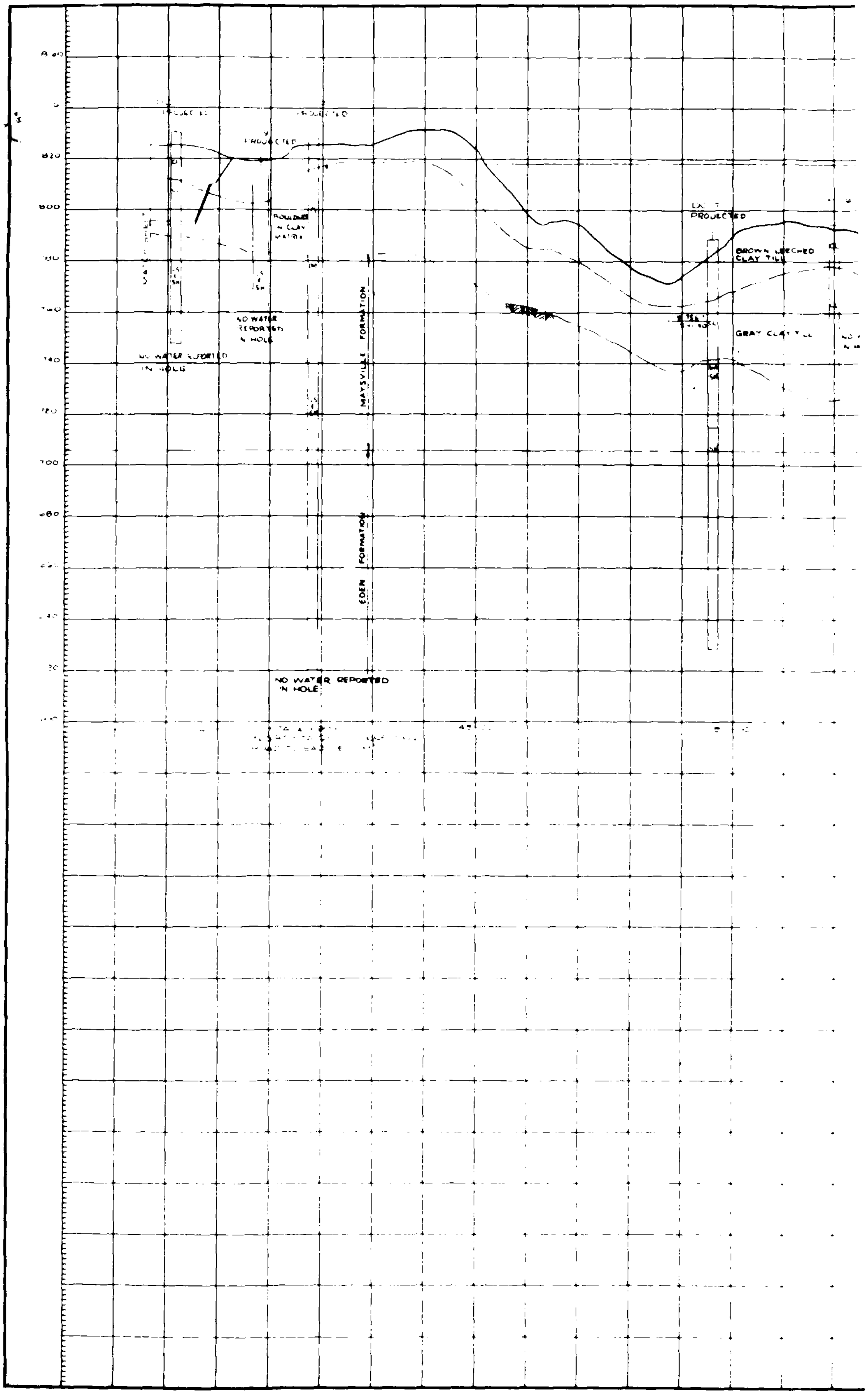
OHIO RIVER BASIN
EAST FORK RESERVOIR
EAST FORK LITTLE MIAMI RIVER

GENERAL GEOLOGIC PROFILE
DAM, SPILLWAY & SADDLE DAM
SHEET 1

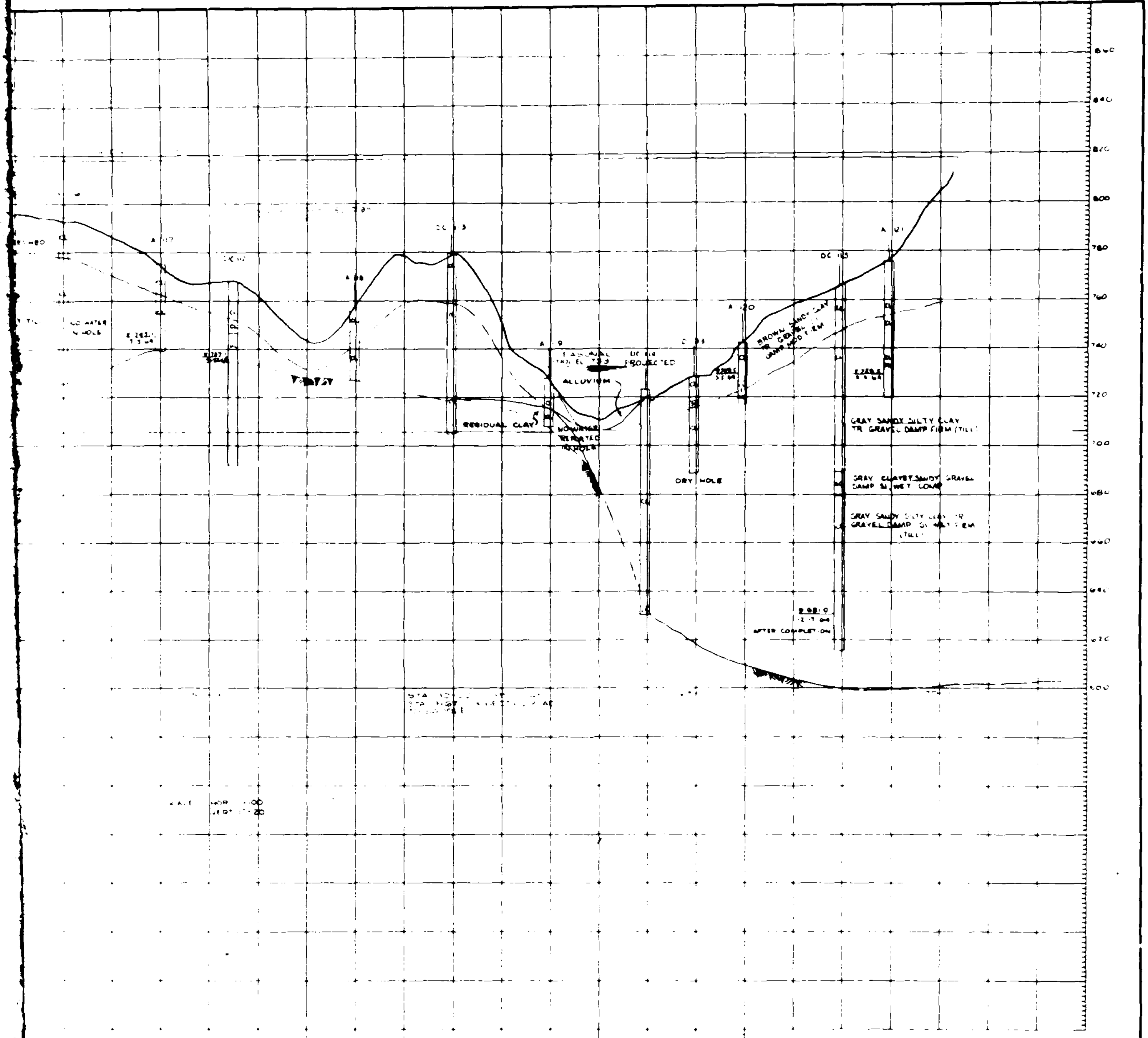
DESIGNED
DRAWN
TRACED RLM
CHECKED
SUBMITTED
APPROVAL RECM
ASST CHIEF ENGINEERING DIV
APPROVED
CHIEF ENGINEERING DIVISION
APPROVED
COL. CORPS OF ENGINEERS DISTRICT ENGINEER
DATE SEPT 1965
SCALE
DRAWING NUMBER

M NO 5

CORPS OF ENGINEERS



U S ARMY



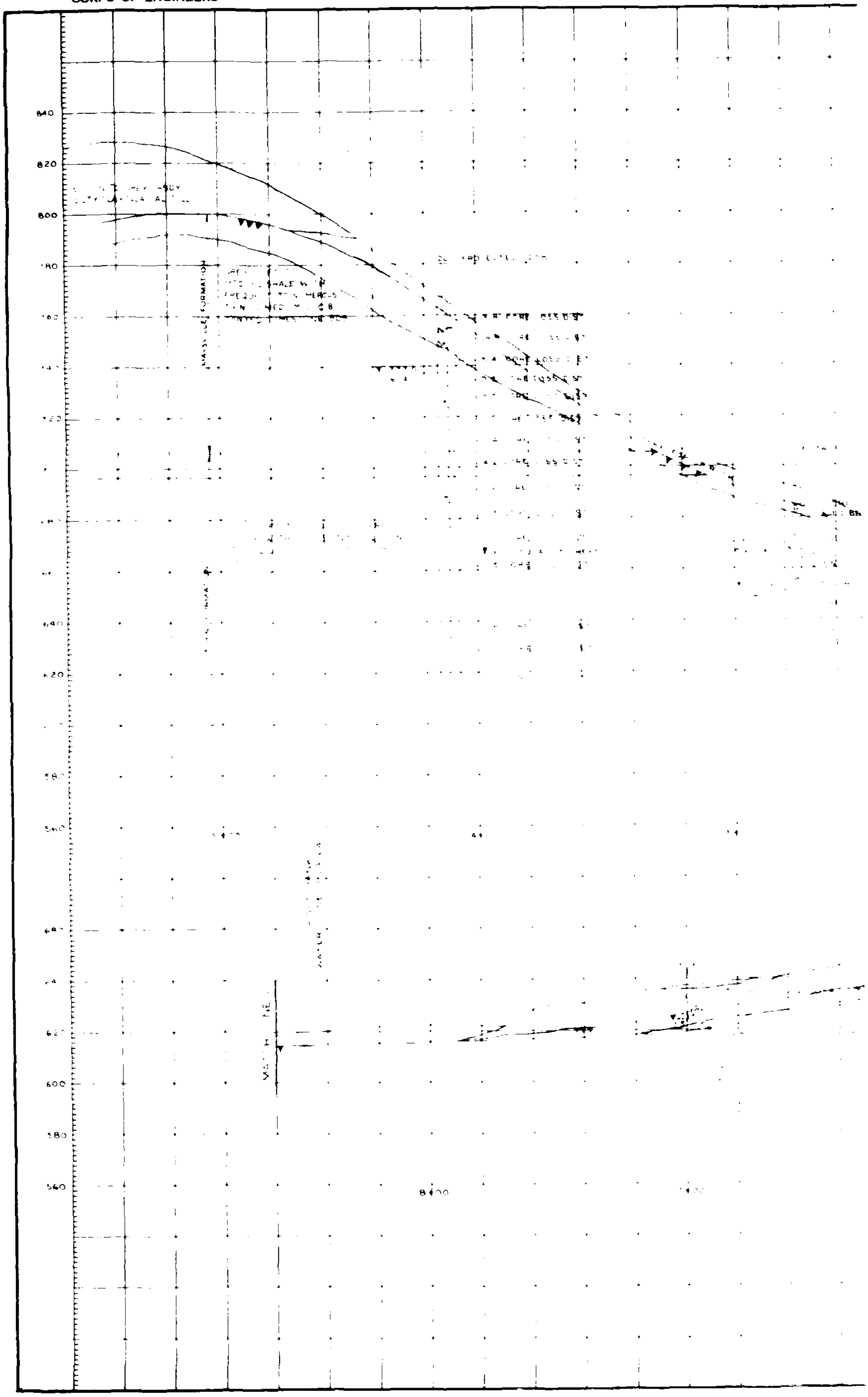
REVISION	DATE	DESCRIPTION

U.S. ARMY ENGINEER DISTRICT, LOUISVILLE
CORPS OF ENGINEERS
LOUISVILLE KENTUCKY

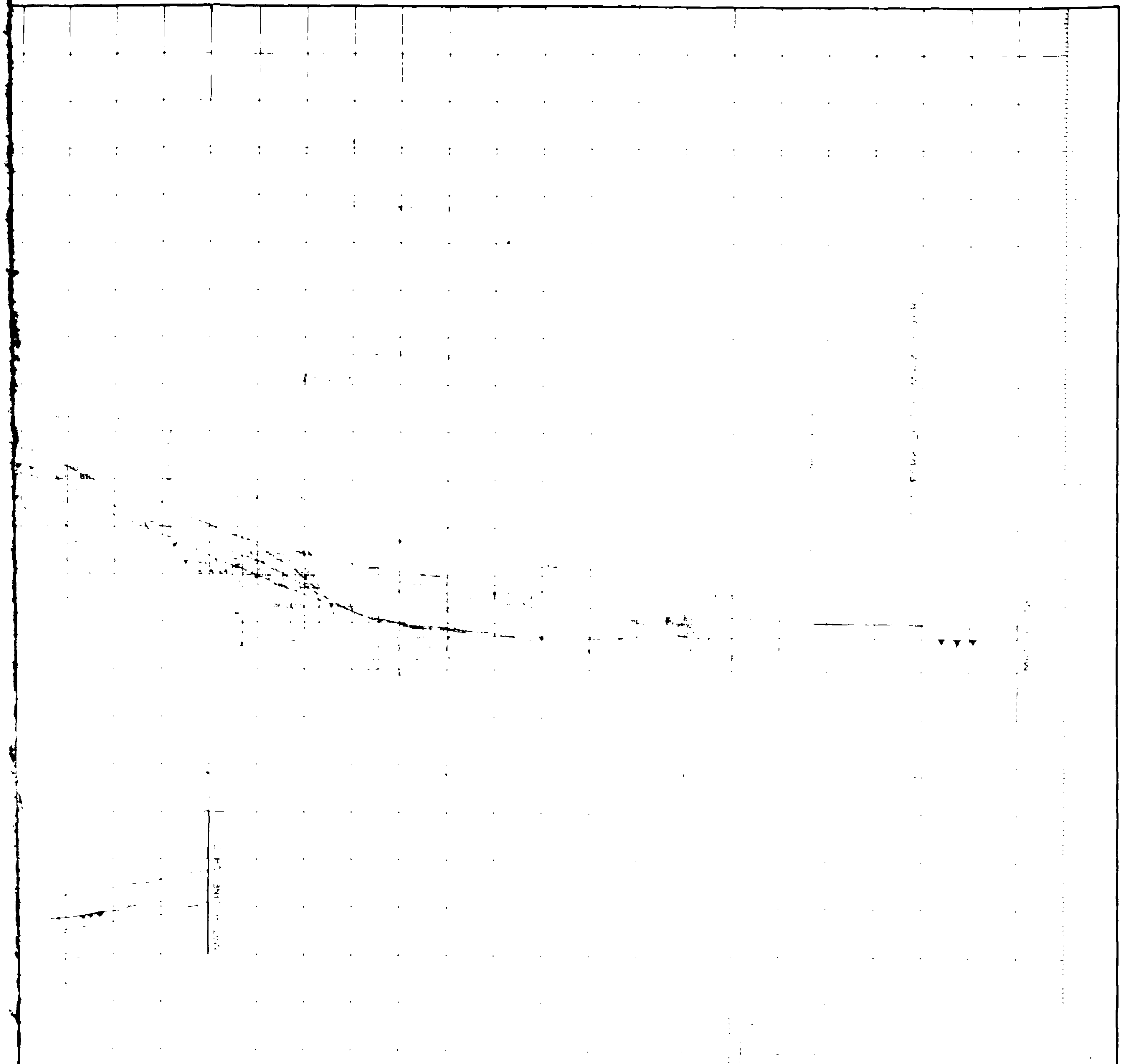
OHIO RIVER BASIN
EAST FORK RESERVOIR
EAST FORK LITTLE MIAMI RIVER
GENERAL GEOLOGIC PROFILE
DAM, SPILLWAY & SADDLE DAM
SHEET 2

DESIGNED
DRAWN TRACED R.C.H.
CHECKED
SUBMITTED
APPROVAL RECM
ASST CHIEF ENGINEERING DIV
APPROVED
COL. CORPS OF ENGINEERS DISTRICT ENGINEER
DATE SEPT 1965
APPROVED
CHIEF ENGINEERING DIVISION
SCALE
DRAWING NUMBER

CORPS OF ENGINEERS



U S ARMY



REVISION | DATE | DESCRIPTION | BY

U S ARMY ENGINEER DISTRICT LOUISVILLE
CORPS OF ENGINEERS

OHIO RIVER BASIN
EAST FORK RESERVOIR
EAST FORK LITTLE MIAMI RIVER

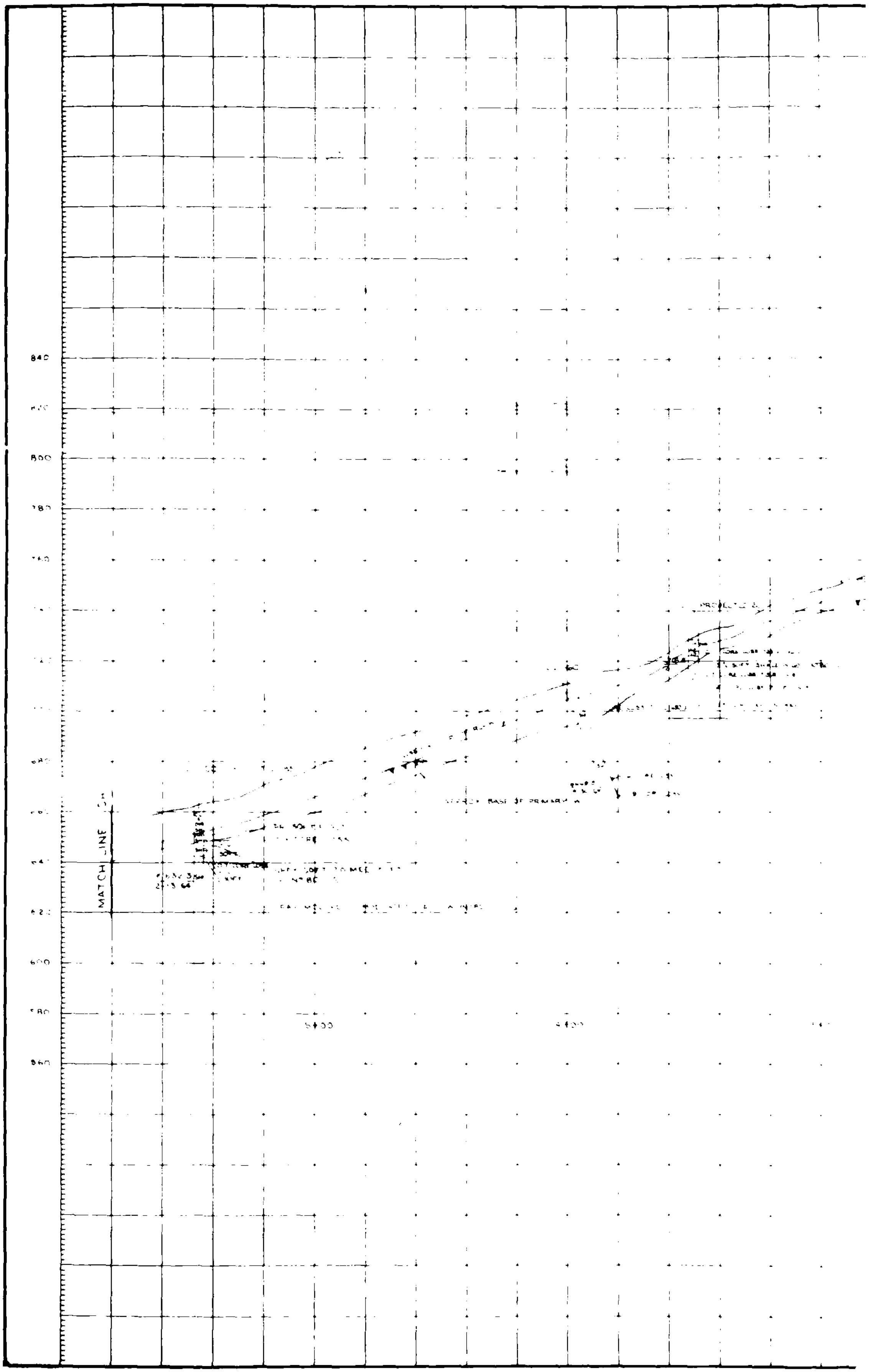
GEOLOGIC PROFILE ALONG DAM

SHEET 1

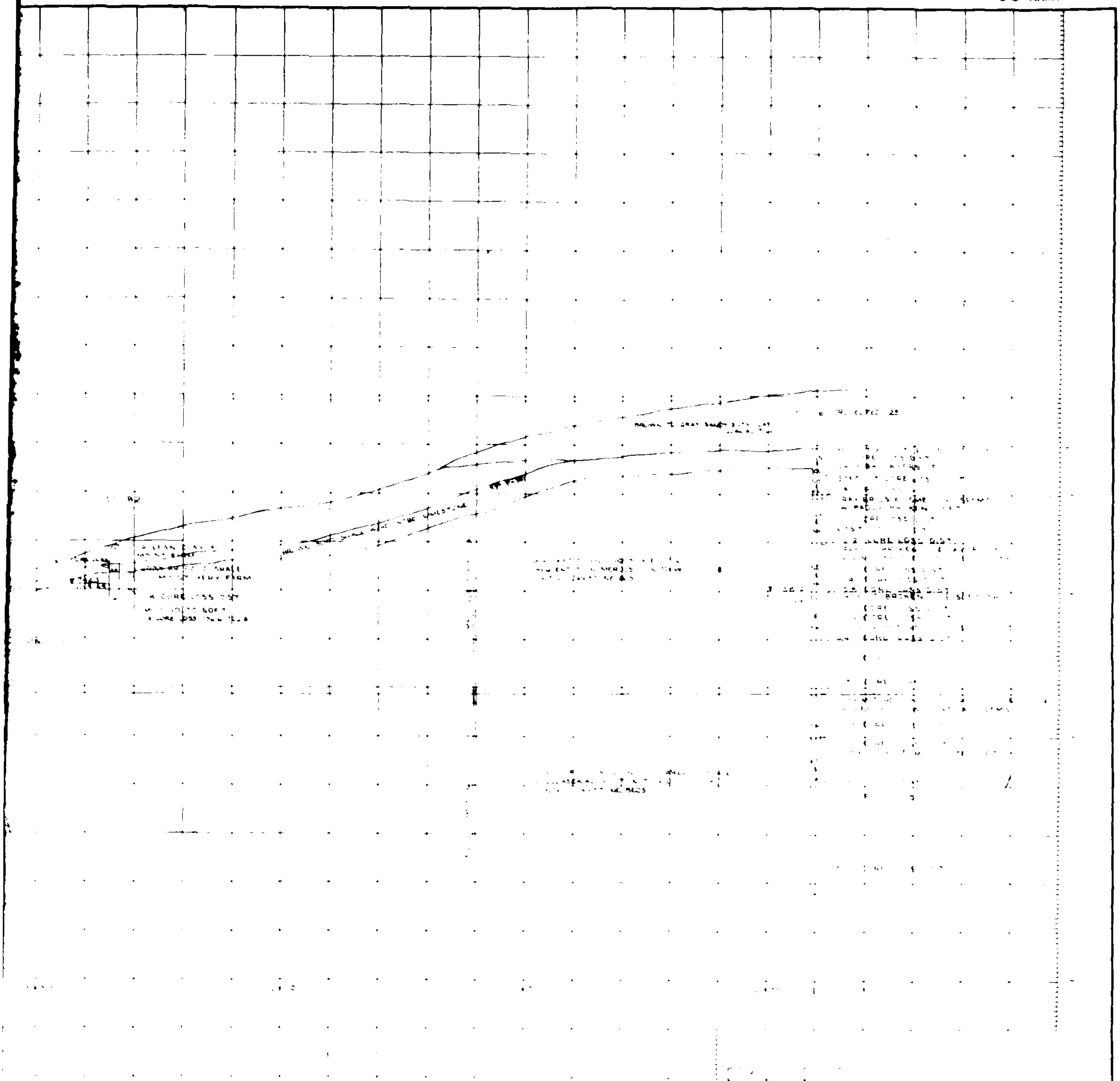
DESIGNED
DRAWN
TRACED
CHECKED
SUBMITTED
APPROVAL RECM
ASST CHIEF ENGINEERING DIV
APPROVED
CHIEF ENGINEERING DIVISION

APPROVED
COL CORPS OF ENGINEERS DISTRICT ENGINEER
SCALE
DRAWING NUMBER

CORPS OF ENGINEERS



U S ARMY



REVISION	DATE	DESCRIPTION	BY

U S ARMY ENGINEER DISTRICT, LOUISVILLE
CORPS OF ENGINEERS
LOUISVILLE KENTUCKY

OHIO RIVER BASIN
EAST FORK RESERVOIR
EAST FORK LITTLE MIAMI RIVER

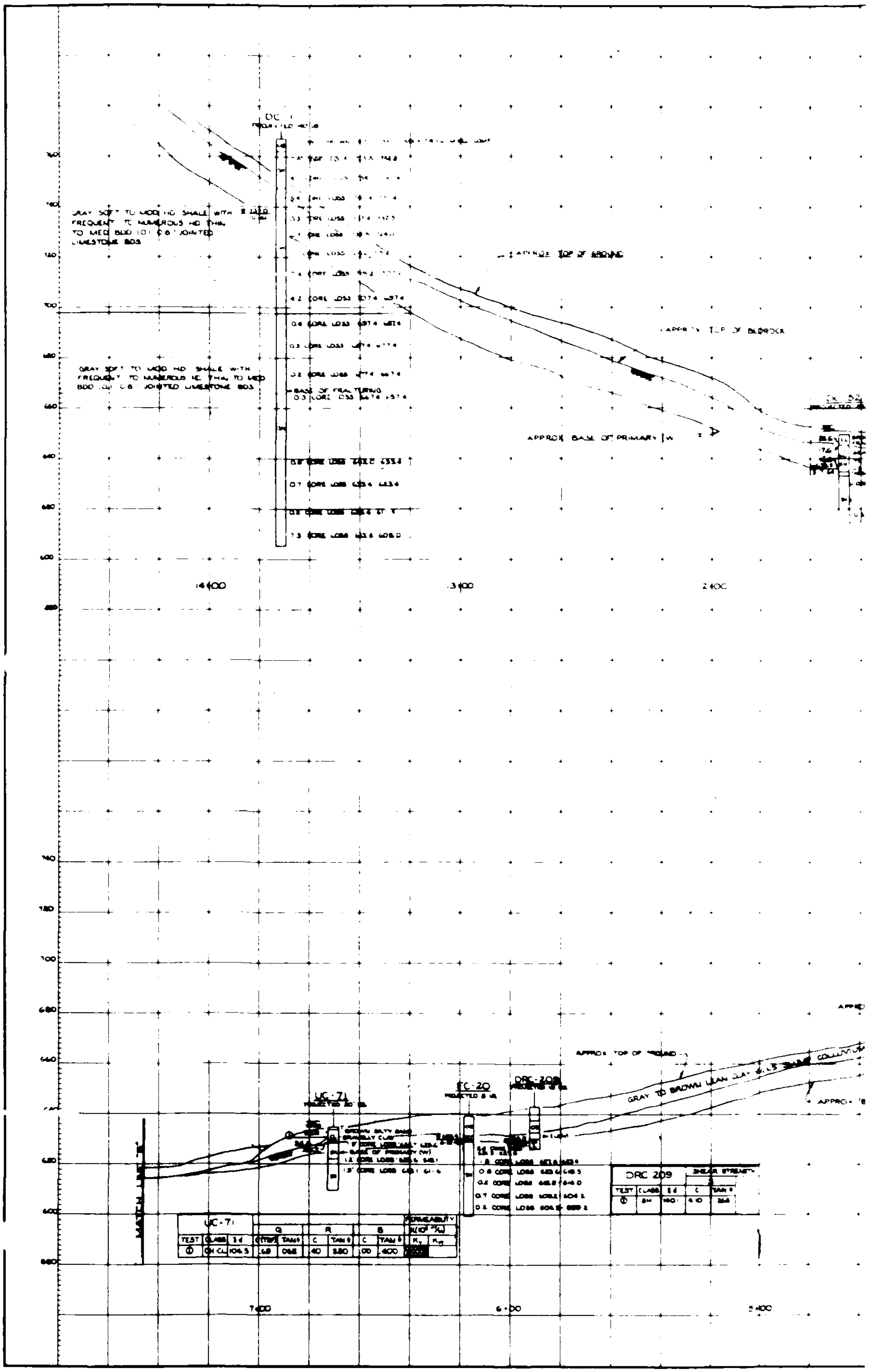
GEOLOGIC PROFILE ALONG DAM

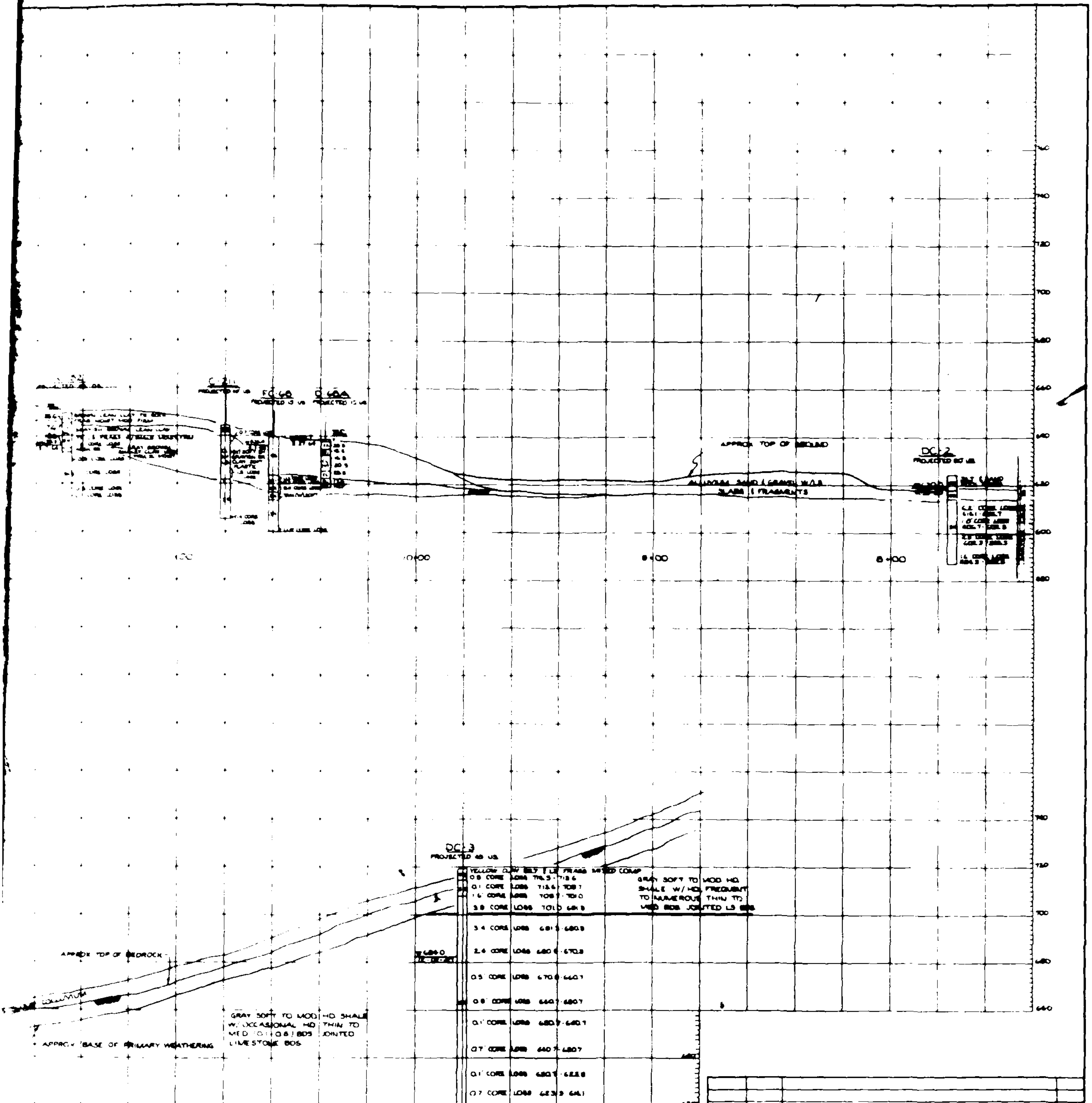
SHEET 2

DESIGNED
DRAWN TRACED
CHECKED
SUBMITTED
APPROVAL RECOM
ASST CHIEF ENGINEERING DIV
APPROVED
CHIEF ENGINEERING DIVISION

APPROVED
COL CORPS OF ENGINEERS DISTRICT ENGINEER
DATE
SCALE
DRAWING NUMBER

CORPS OF ENGINEERS





REVISION	DATE	DESCRIPTION	BY

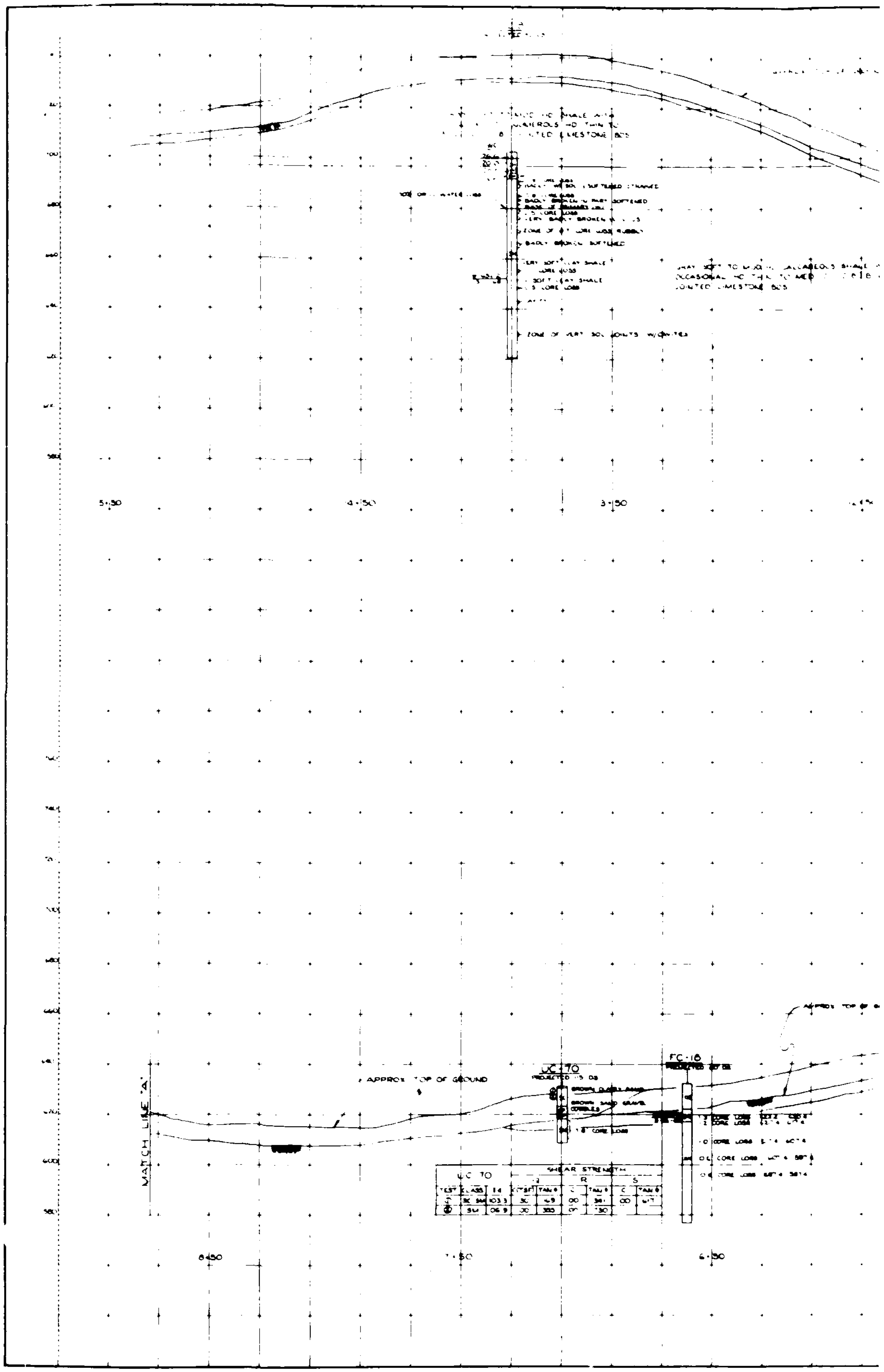
U. S. ARMY ENGINEER DISTRICT, LOUISVILLE
CORPS OF ENGINEERS
LOUISVILLE KENTUCKY

DESIGNED
DRAWN
TRACED BMO
CHECKED
SUBMITTED

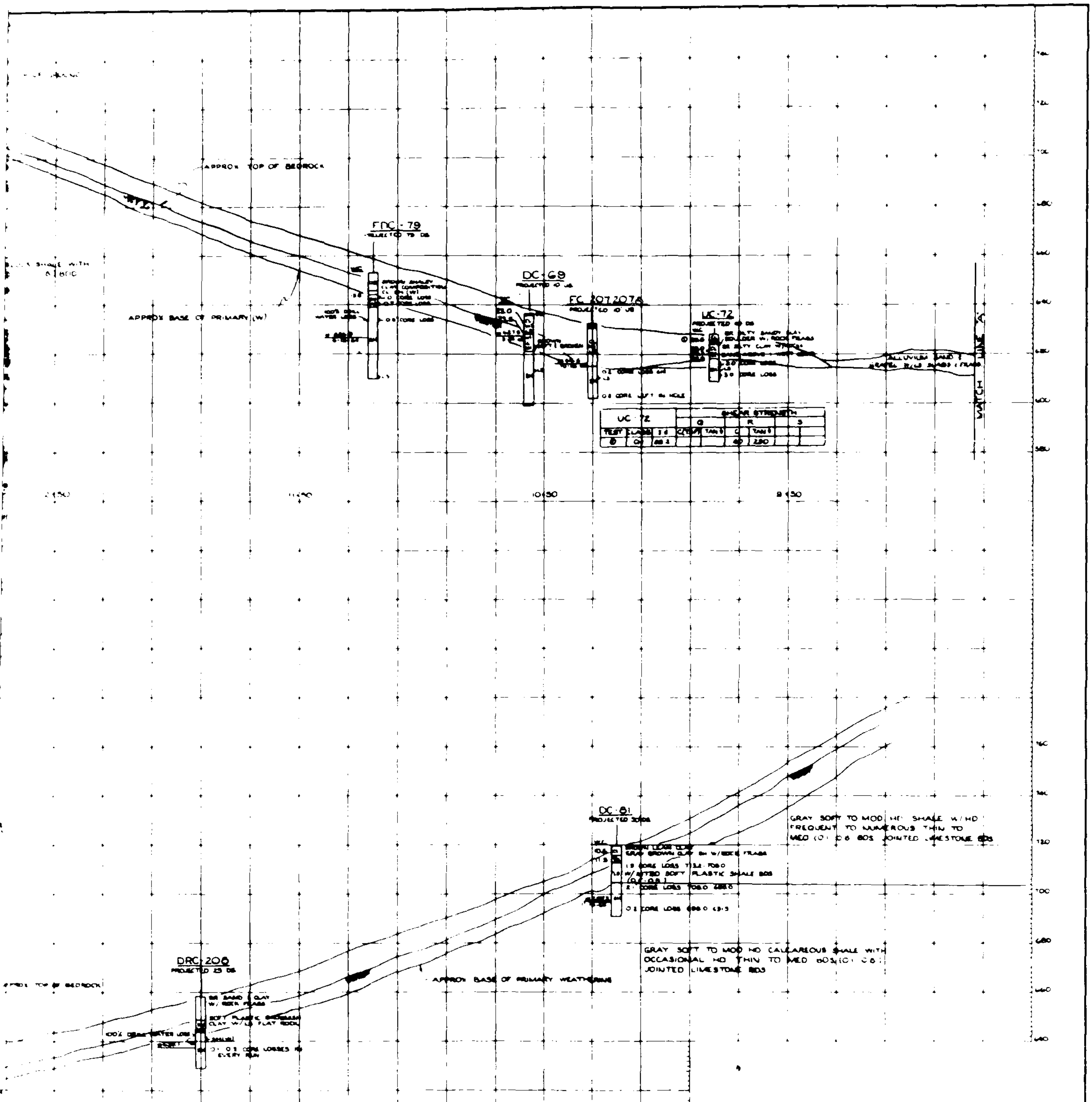
OHIO RIVER BASIN
EAST FORK RESERVOIR
EAST FORK LITTLE MIAMI RIVER
GEOLOGIC PROFILE
PARALLEL TO ℄ DAM
350' UPSTREAM

SCALE
DATE
DRAWING NUMBER

CORPS OF ENGINEERS



U. S. ARMY



REVISION	DATE	DESCRIPTION	BY

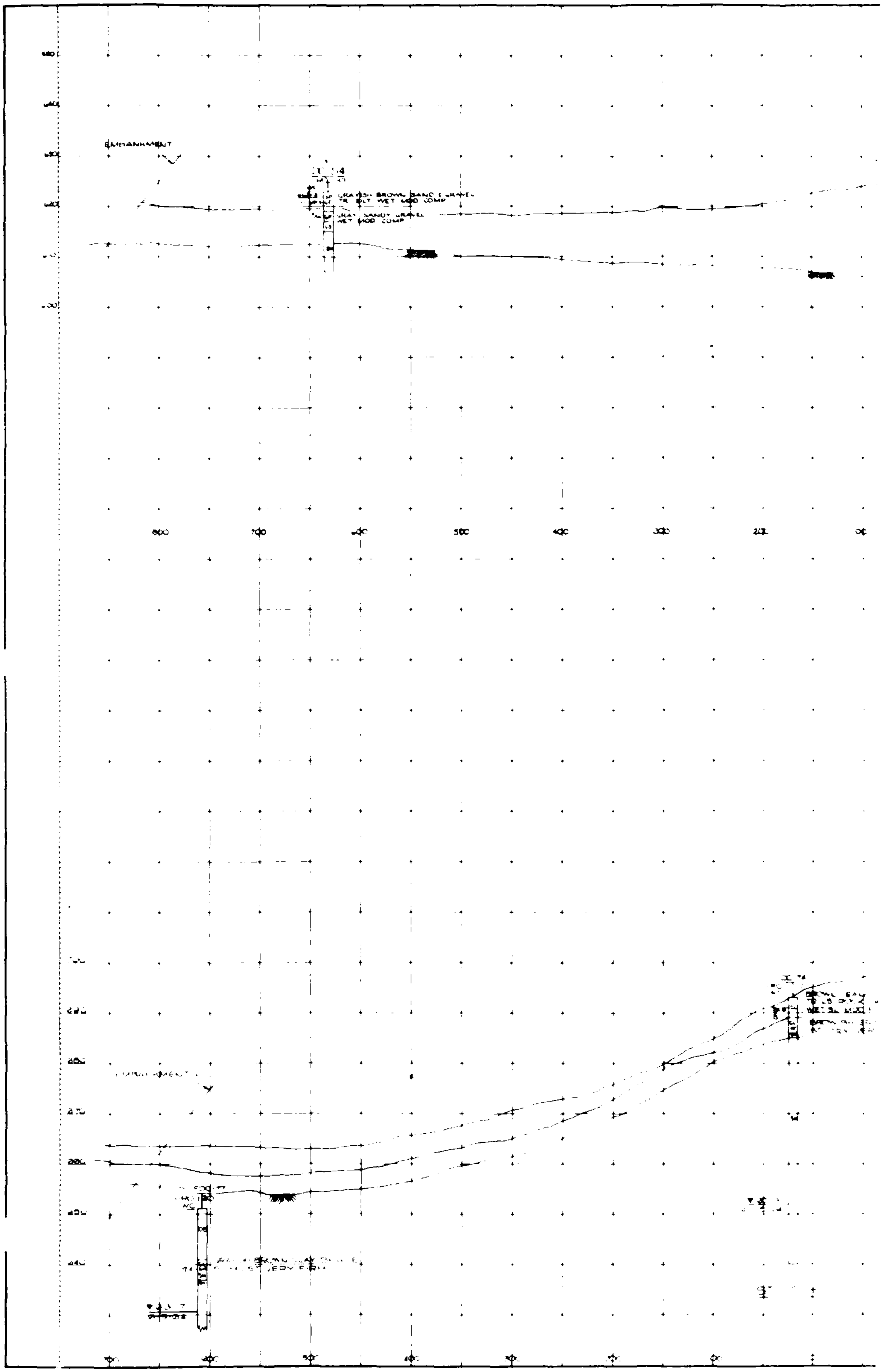
U. S. ARMY ENGINEER DISTRICT, LOUISVILLE
CORPS OF ENGINEERS
LOUISVILLE, KENTUCKY

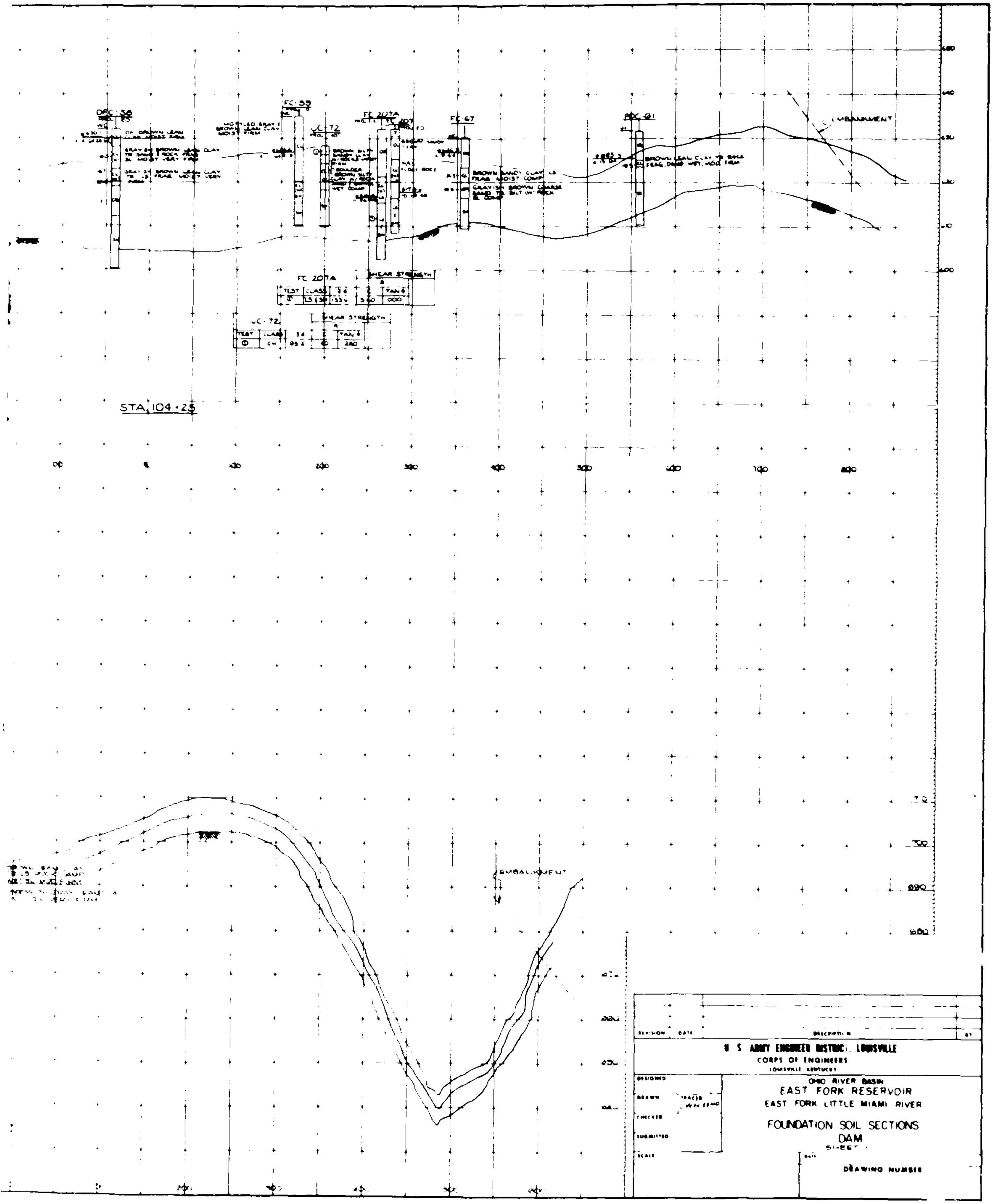
DESIGNED	
DRAWN	TRACED SMD
CHECKED	
SUBMITTED	
SCALE	

OHIO RIVER BASIN
EAST FORK RESERVOIR
EAST FORK LITTLE MIAMI RIVER
GEOLOGIC PROFILE
PARALLEL TO ℄ DAM
250' DOWNSTREAM

DATE
DRAWING NUMBER

CORPS OF ENGINEERS





U S ARMY ENGINEER DISTRICT, LOUISVILLE
CORPS OF ENGINEERS
LOUISVILLE KENTUCKY

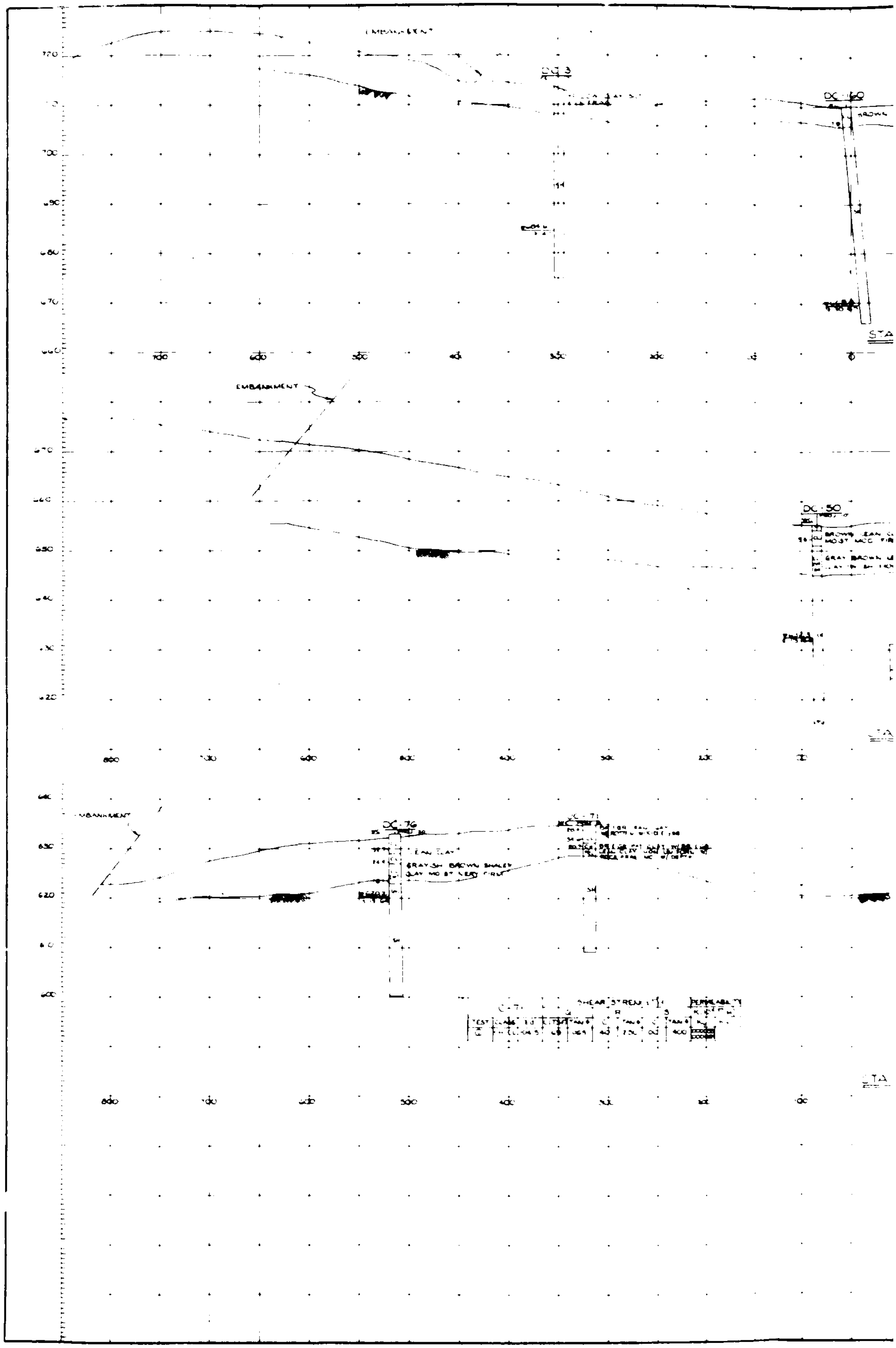
OHIO RIVER BASIN
EAST FORK RESERVOIR
EAST FORK LITTLE MIAMI RIVER

FOUNDATION SOIL SECTIONS
DAM

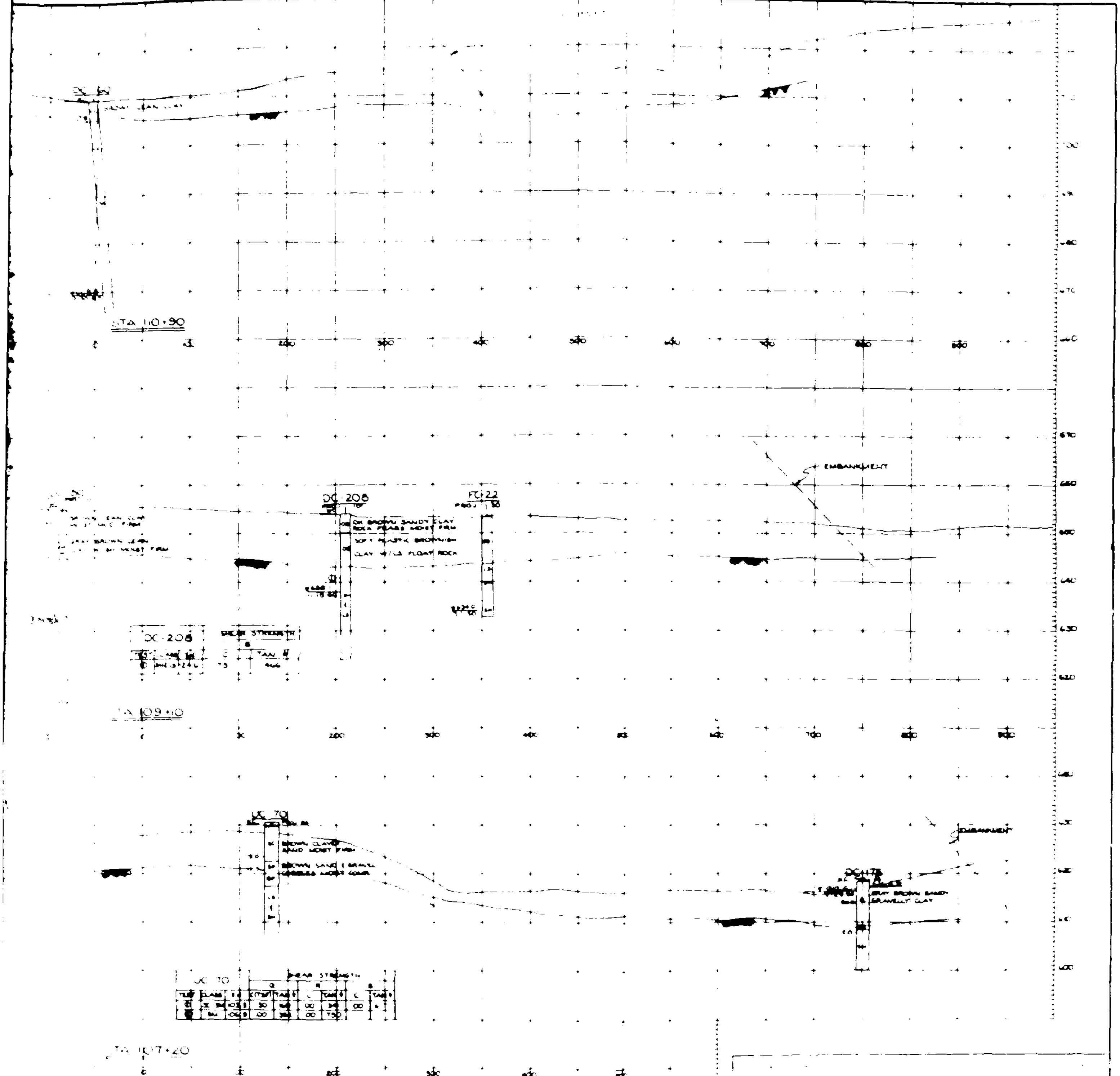
REVISION	DATE	DESCRIPTION	BY

DESIGNED
DRAWN
TRACED
CHECKED
SUBMITTED
SCALE
DRAWING NUMBER

CORPS OF ENGINEERS



U S ARMY



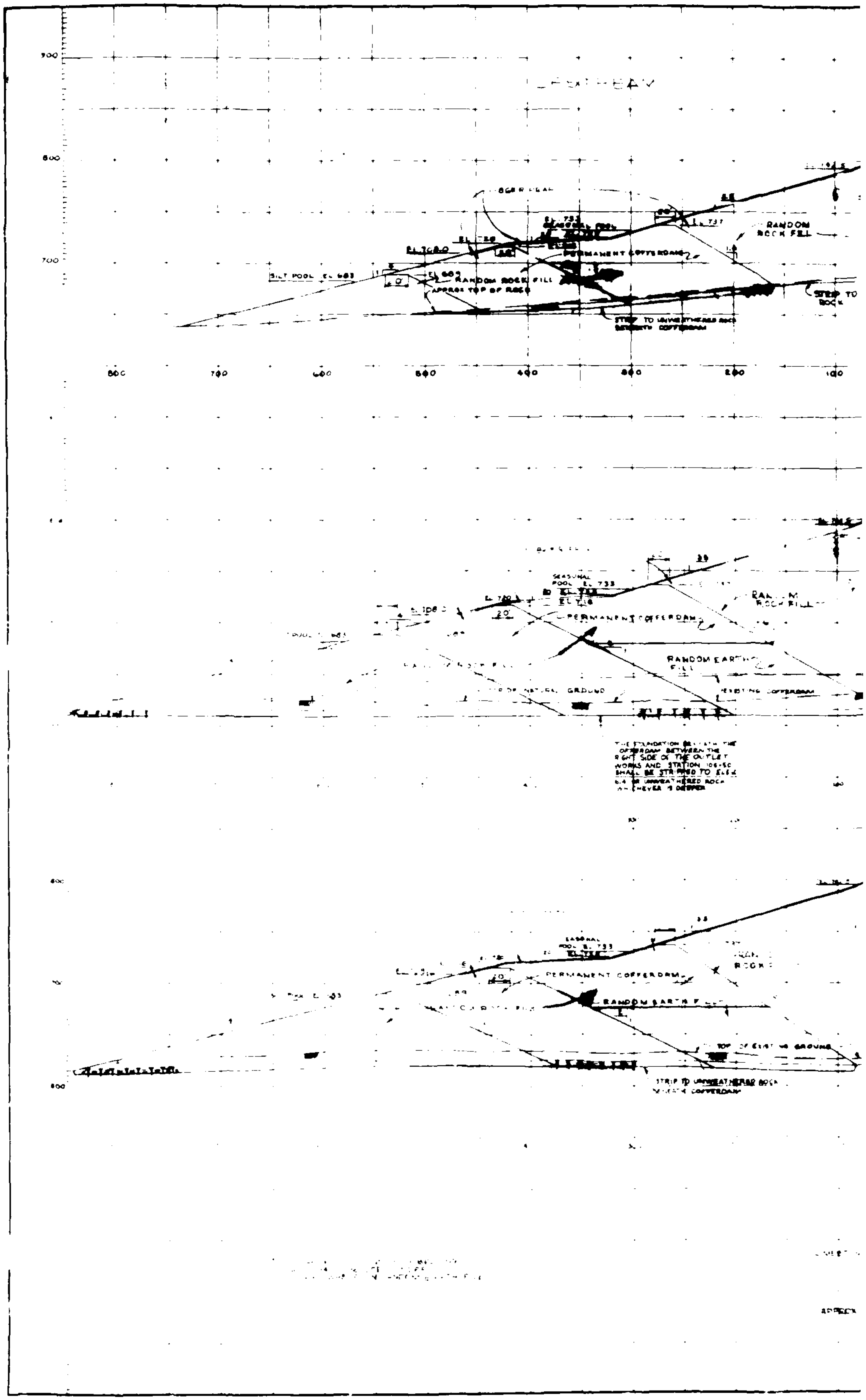
U S ARMY ENGINEER DISTRICT LOUISVILLE
CORPS OF ENGINEERS
LOUISVILLE KENTUCKY

OHIO RIVER BASIN
EAST FORK RESERVOIR
EAST FORK LITTLE MIAMI RIVER

FOUNDATION SOIL SECTIONS
DAM
SHEET 2

DRAWING NUMBER

CORPS OF ENGINEERS



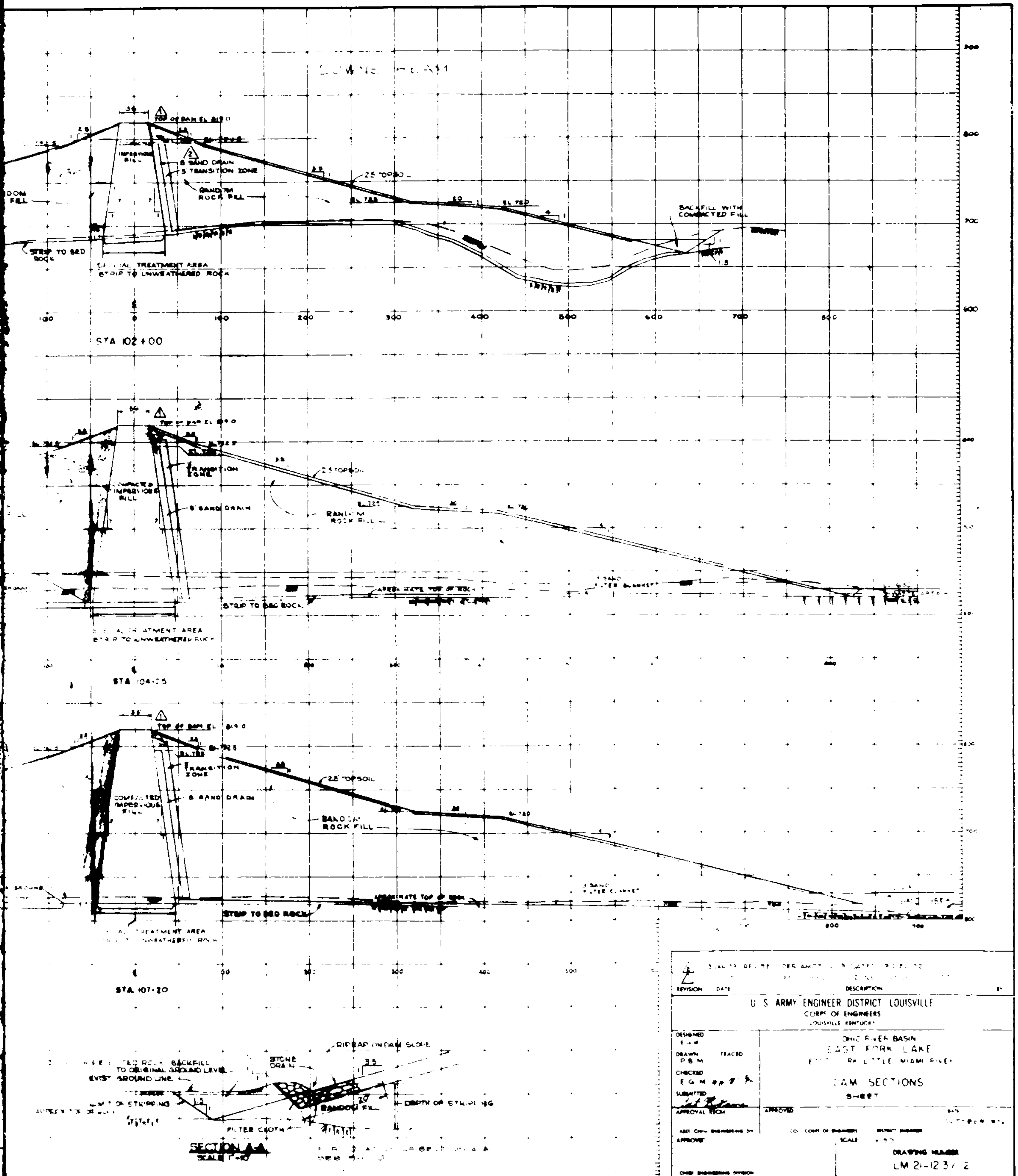
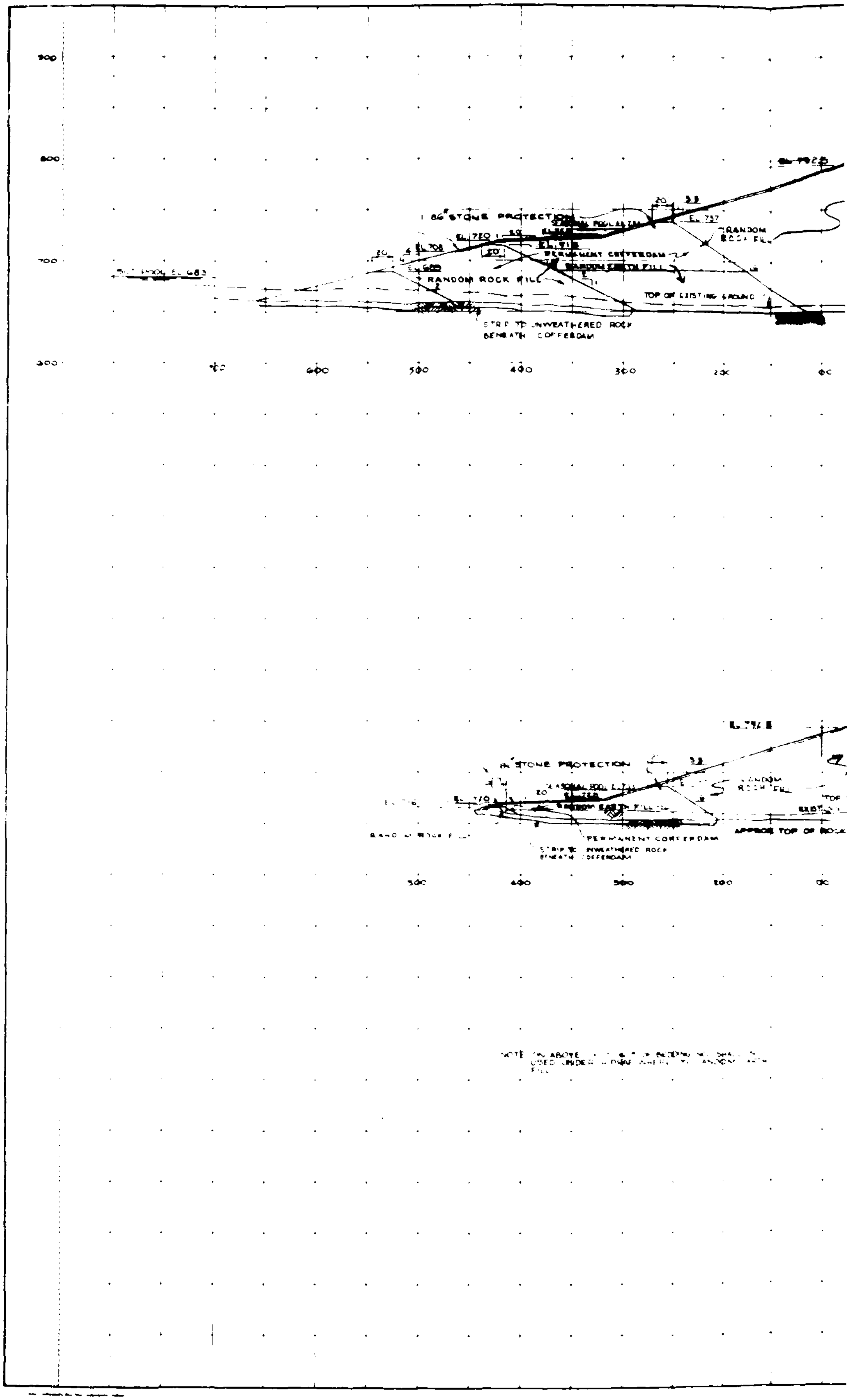
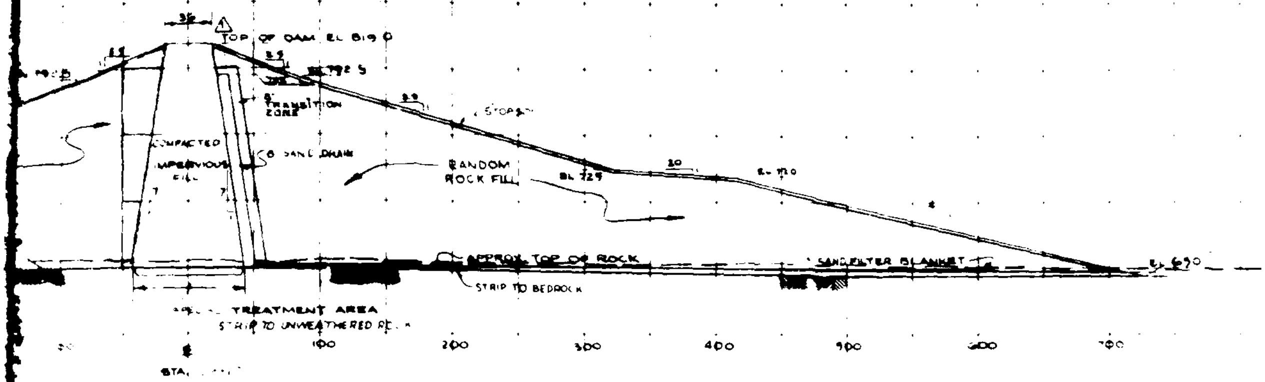


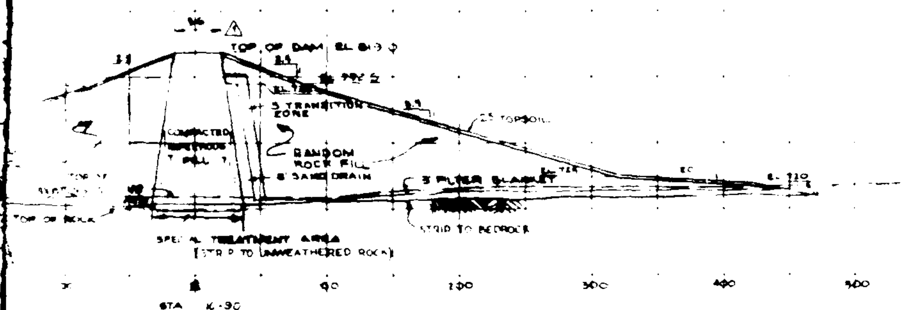
EXHIBIT [redacted]

CORPS OF ENGINEERS



U S ARMY





REVISION	DATE	DESCRIPTION	BY

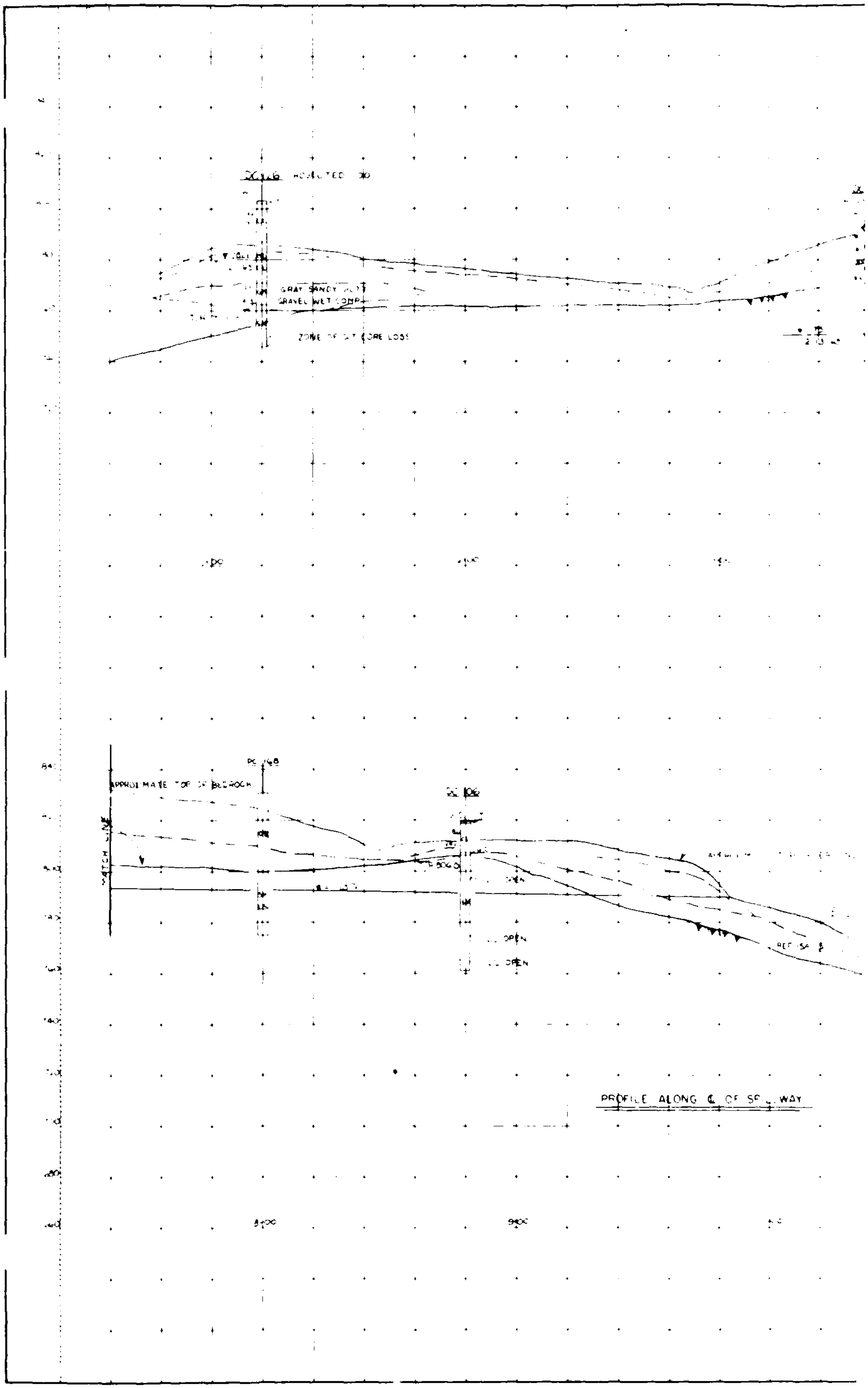
U S ARMY ENGINEER DISTRICT, LOUISVILLE
CORPS OF ENGINEERS
LOUISVILLE KENTUCKY

OHIO RIVER BASIN
EAST FORK LAKE
EAST FORK LITTLE MIAMI RIVER

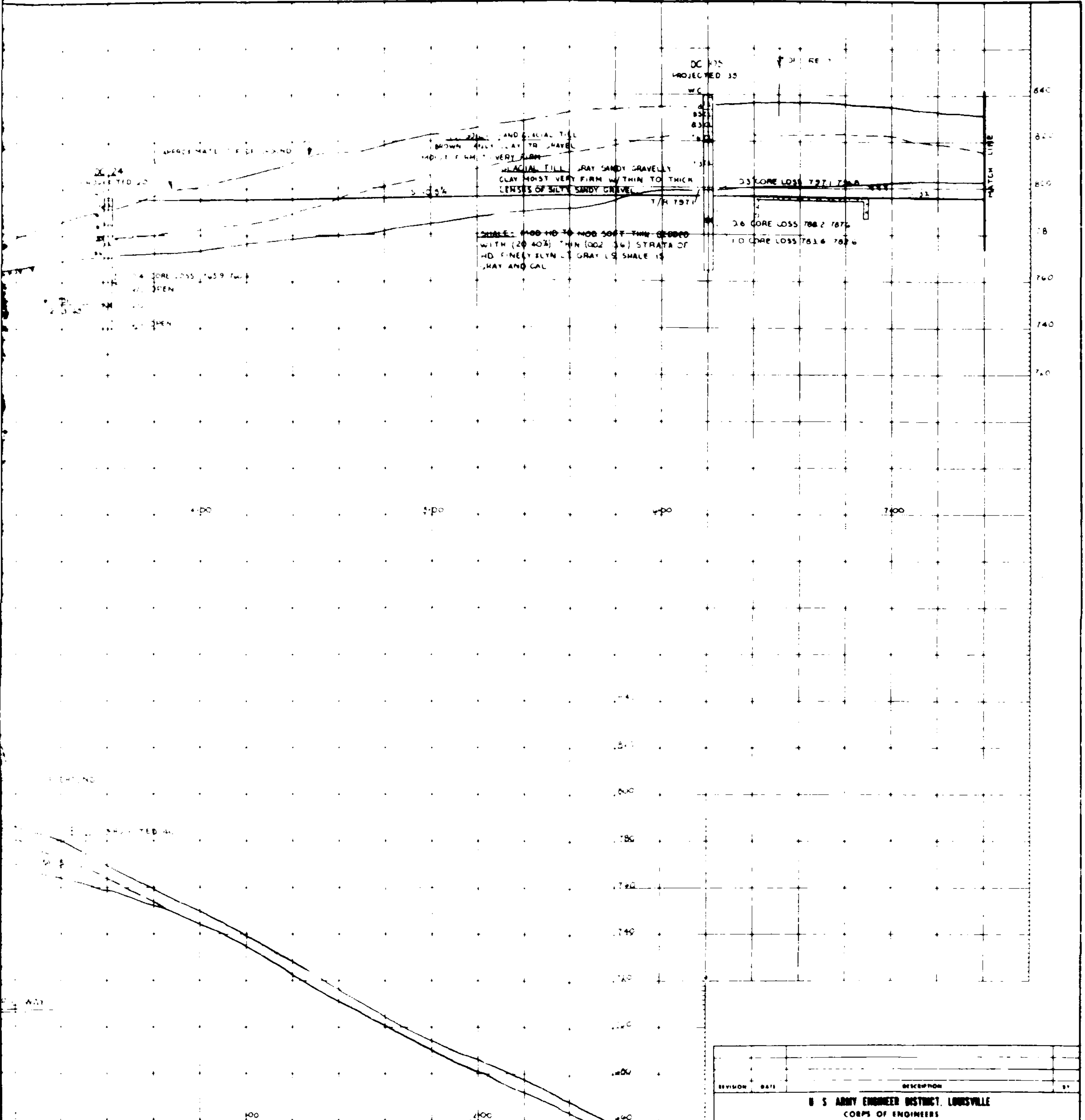
DAM SECTIONS
SHEET 2

DESIGNED E G M
DRAWN B M
TRACED
CHECKED E G M
SUBMITTED
SCALE 1"=50'
DATE OCTOBER 1972
DRAWING NUMBER

EXHIBIT


GRAY SANDY
GRAVEL WET COMP
APPROXIMATE TOP OF BEDROCK
MATCH LINE
OPEN
OPEN
8+00
9+00

U. S. ARMY



REVISION	DATE	DESCRIPTION	BY

U. S. ARMY ENGINEER DISTRICT, LOUISVILLE
CORPS OF ENGINEERS
LOUISVILLE, KENTUCKY

DESIGNED
DRAWN TRACED JLD
CHECKED
SUBMITTED
SCALE

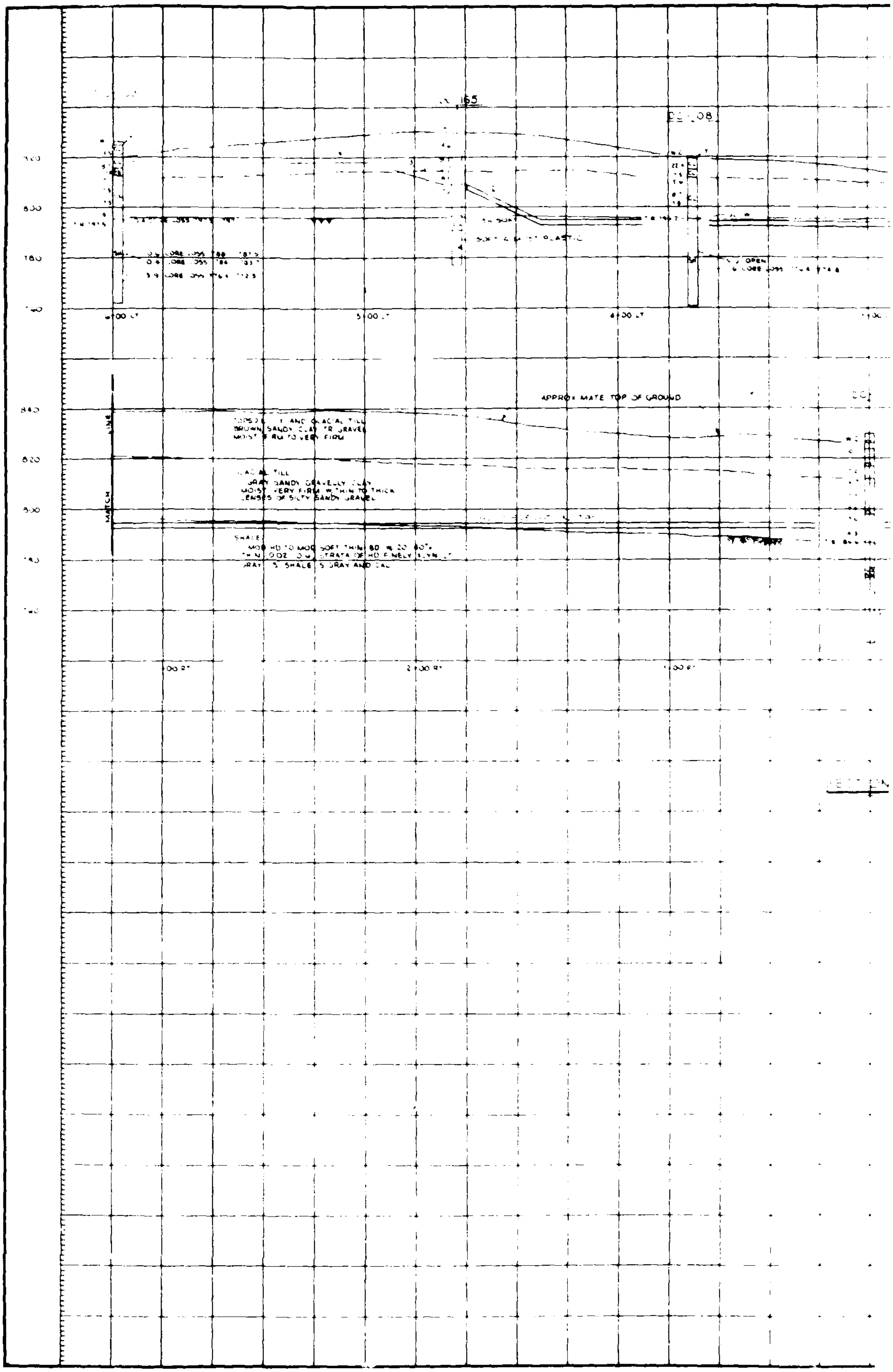
OHIO RIVER BASIN
EAST FORK RESERVOIR
EAST FORK LITTLE MIAMI RIVER
GEOLOGIC PROFILE
SPILLWAY

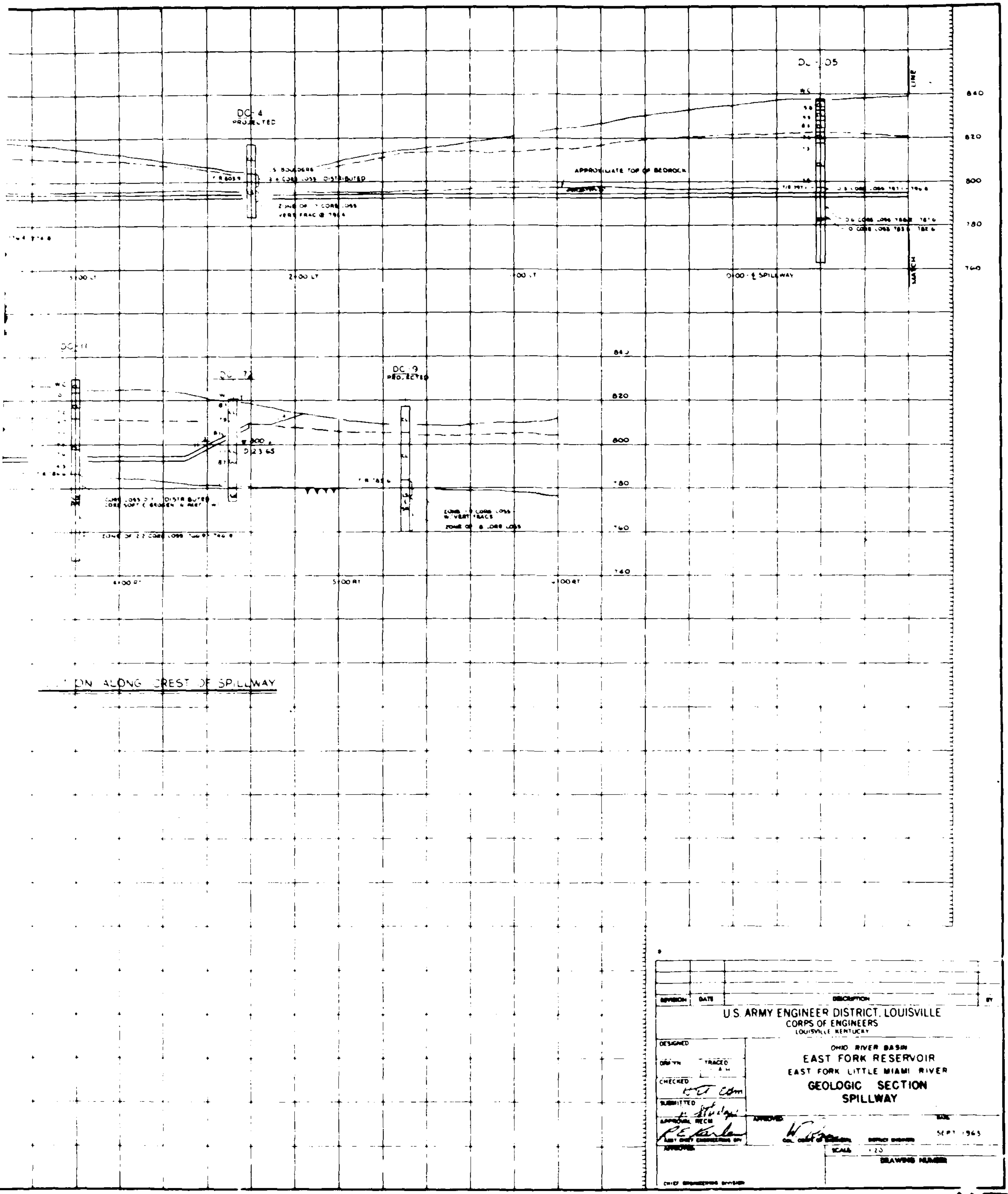
DRAWING NUMBER

DM 5

PLATE [redacted]

COR OF ENGINEERS





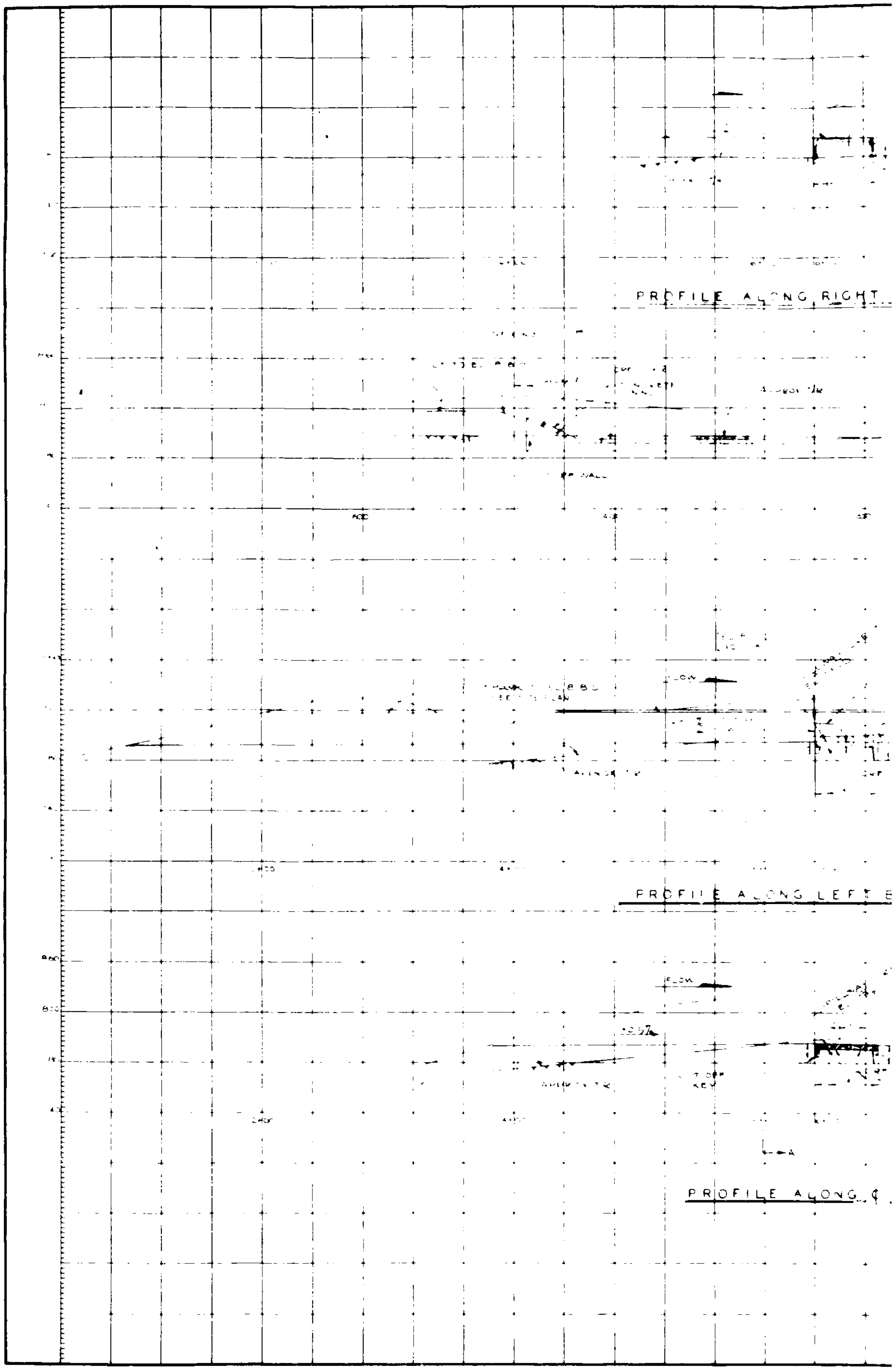
REVISION	DATE	DESCRIPTION	BY

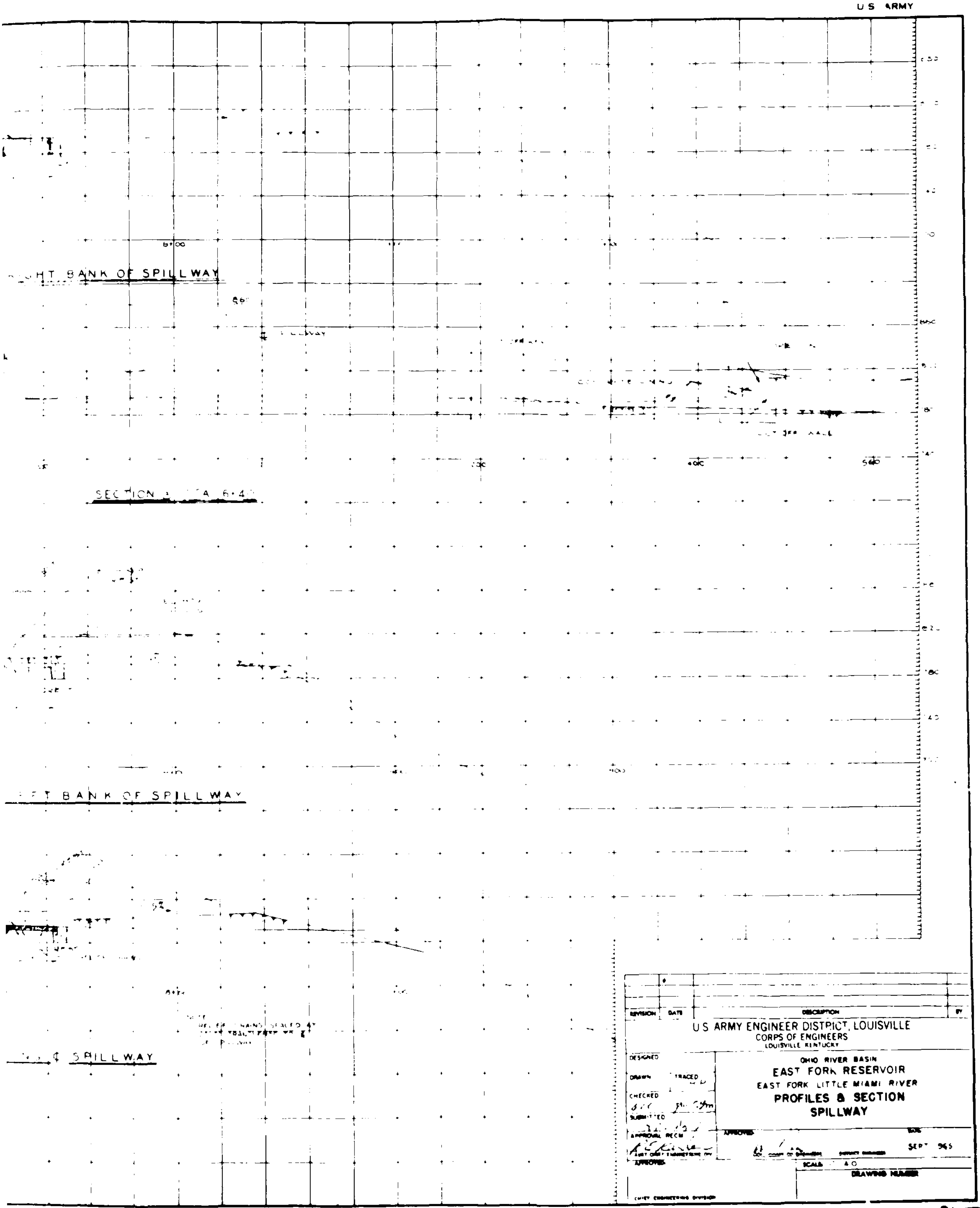
U.S. ARMY ENGINEER DISTRICT, LOUISVILLE
CORPS OF ENGINEERS
LOUISVILLE, KENTUCKY

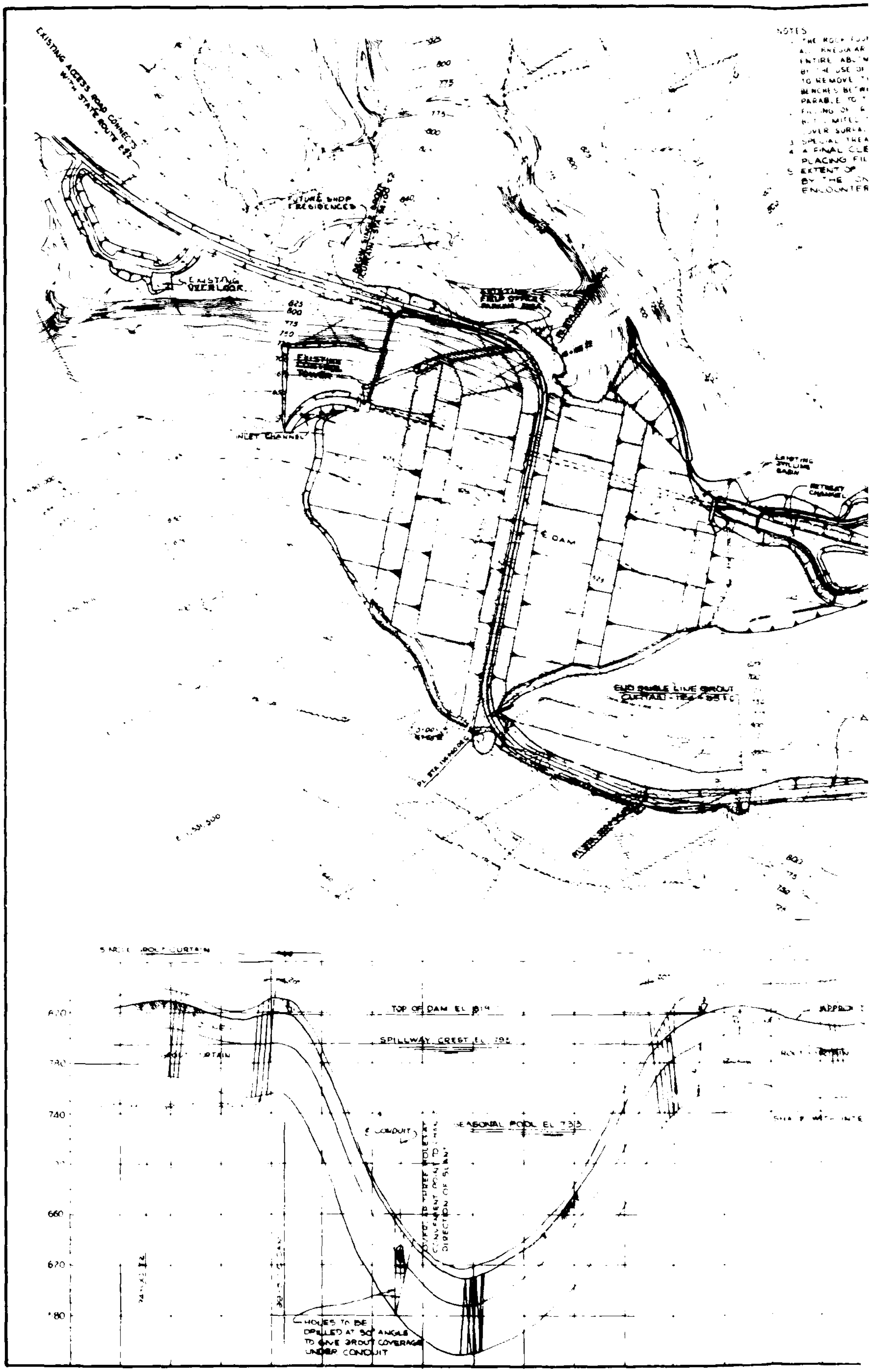
OHIO RIVER BASIN
EAST FORK RESERVOIR
EAST FORK LITTLE MIAMI RIVER
GEOLOGIC SECTION
SPILLWAY

DESIGNED
DRAWN
TRACED
CHECKED
SUBMITTED
APPROVAL RECM
APPROVED
CHIEF ENGINEERING DIVISION
DATE SEPT 1965
SCALE
DRAWING NUMBER

CORPS OF ENGINEERS




U S ARMY
HT BANK OF SPILLWAY
6+00
SECTION
FT BANK OF SPILLWAY
SPILLWAY
REVISION
DATE
DESCRIPTION
BY
U S ARMY ENGINEER DISTRICT, LOUISVILLE
CORPS OF ENGINEERS
LOUISVILLE KENTUCKY
DESIGNED
DRAWN
TRACED
CHECKED
SUBMITTED
APPROVAL RECM
APPROVED
CHIEF ENGINEERING DIVISION
OHIO RIVER BASIN
EAST FORK RESERVOIR
EAST FORK LITTLE MIAMI RIVER
PROFILES & SECTION
SPILLWAY
APPROVED
SCALE
DRAWING NUMBER



EXISTING ACCESS ROAD CONNECTS WITH STATE ROUTE 282
FUTURE SHOP RESIDENCES
EXISTING OVERLOOK
EXISTING CONTROL TOWER
INLET CHANNEL
EXISTING FIELD OFFICE PARKING AREA
℄ DAM
END DOUBLE LINE GROUT CURTAIN
NOTES
A FINAL CLE
PLACING FIL
EXTENT OF
BY THE
ENCOUNTER
TOP OF DAM EL 814
SPILLWAY CREST EL 795
SEASONAL POOL EL 735
℄ CONDUIT
HOLES TO BE DRILLED AT 30° ANGLE TO GIVE GROUT COVERAGE UNDER CONDUIT
DIRECTION OF SLANT
820
780
740
660
620
580

NOTES

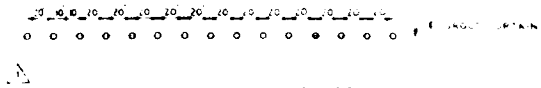
THE ROCK FOUNDATION AND ABUTMENTS SHALL BE CLEANED WITHIN THE LIMITS OF THE SPECIAL TREATMENT AREA. ALL IRREGULARITIES SHALL BE REMOVED OR TRIMMED BACK TO FORM A REASONABLY UNIFORM SLOPE ON THE ENTIRE ABUTMENT. OVERHANGS WILL NOT BE PERMITTED AT ANY LOCATION AND SHALL BE REMEDIED EITHER BY THE USE OF CONCRETE "DENTAL TREATMENT" TO FILL THE DEPRESSIONS, OR BY DRILLING AND BLASTING TO REMOVE THE OVERHANGING ROCK. VERTICAL SURFACES SHALL NOT BE HIGHER THAN 5 FEET AND THE BENCHES BETWEEN VERTICAL SURFACES SHALL BE OF SUCH WIDTH AS TO PROVIDE A STEPPED SLOPE COMPARABLE TO THE UNIFORM SLOPE ON ADJACENT AREAS.

[illegible] OF CRACKS OR FISSURES WITHIN THE SPECIAL TREATMENT AREA SHALL BE WITH LEAN CONCRETE [illegible] TO THE OPENINGS IN THE ROCK SURFACE, AND THIN LAYERS OF LEAN CONCRETE SHALL NOT COVER SURFACE AREAS OF SOUND ROCK WHERE IT MIGHT CRACK OFF UNDER ROLLING ACTION.

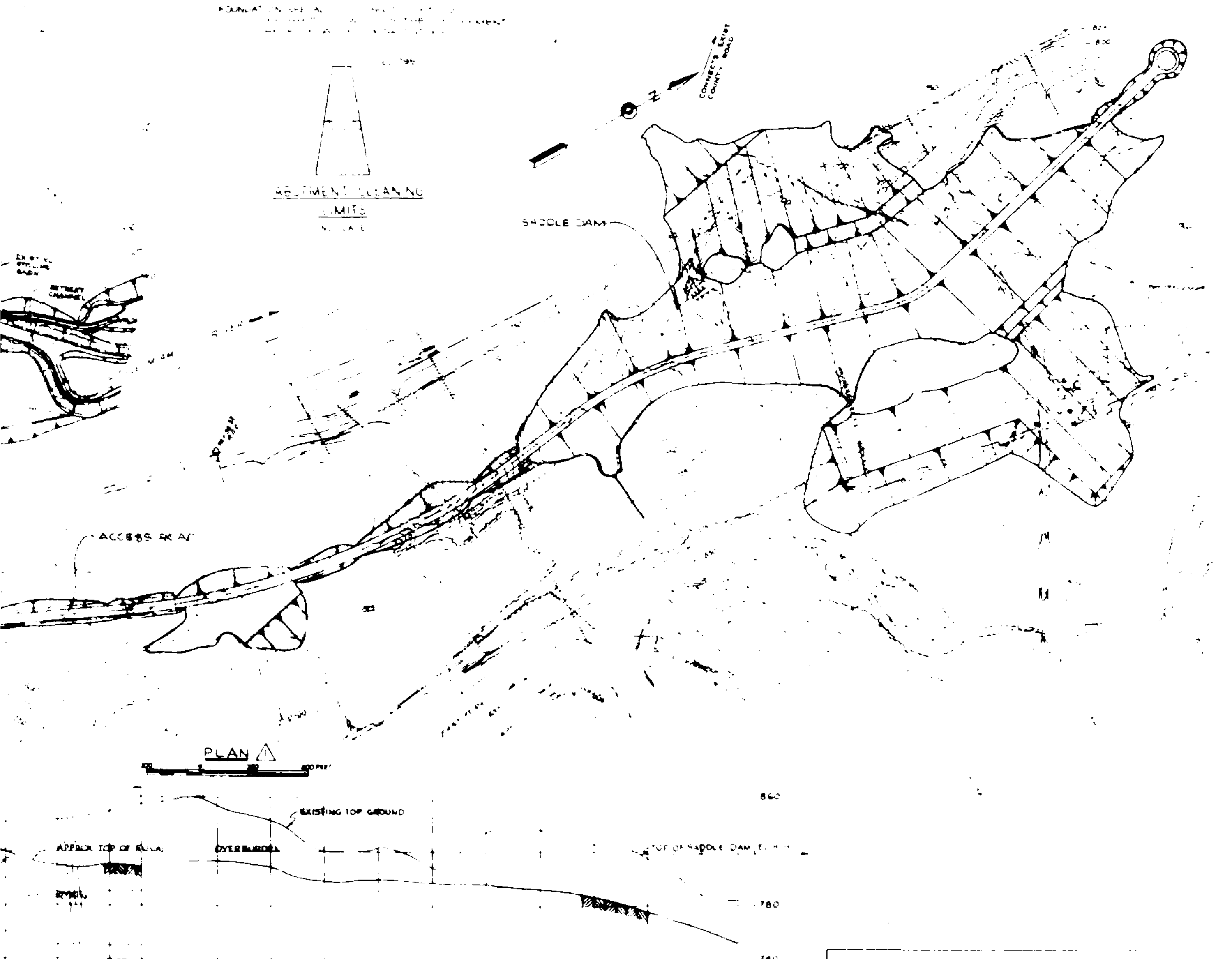
SPECIAL TREATMENT AREA SHALL EXTEND BETWEEN ELEVATION 795 (SPILLWAY CREST), AT EACH ABUTMENT.

A FINAL CLEANUP IN THE SPECIAL TREATMENT AREA SHALL BE MADE JUST PRIOR TO PLACING FILL.

EXTENT OF CUT OFF TRENCH AND GROUT CURTAIN ARE APPROXIMATE AND MAY BE EXTENDED BY THE CONTRACTING OFFICER TO REMOVE PERVIOUS MATERIAL WHICH MAY BE ENCOUNTERED FURTHER IN THE ABUTMENTS.



GROUT CURTAIN SPACING



REVISION	DATE	DESCRIPTION

U S ARMY ENGINEER DISTRICT LOUISVILLE
CORPS OF ENGINEERS
LOUISVILLE KENTUCKY

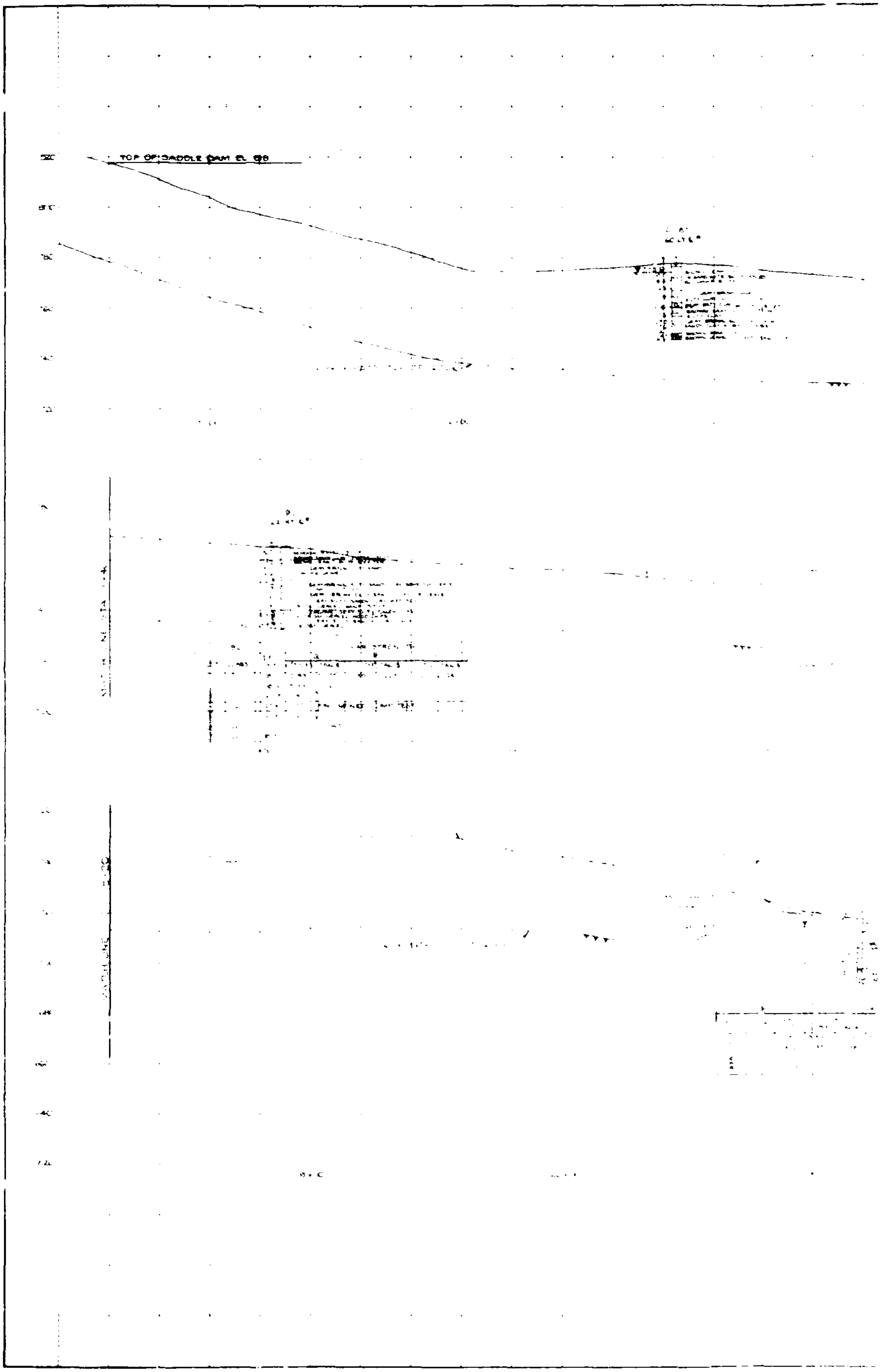
DESIGNED
DRAWN TRACED
CHECKED H E T
SUBMITTED
APPROV. & RECM
APPROVED

OHIO RIVER BASIN
EAST FORK RESERVOIR
EAST FORK LITTLE MIAMI RIVER
GROUTING PLAN & PROFILE

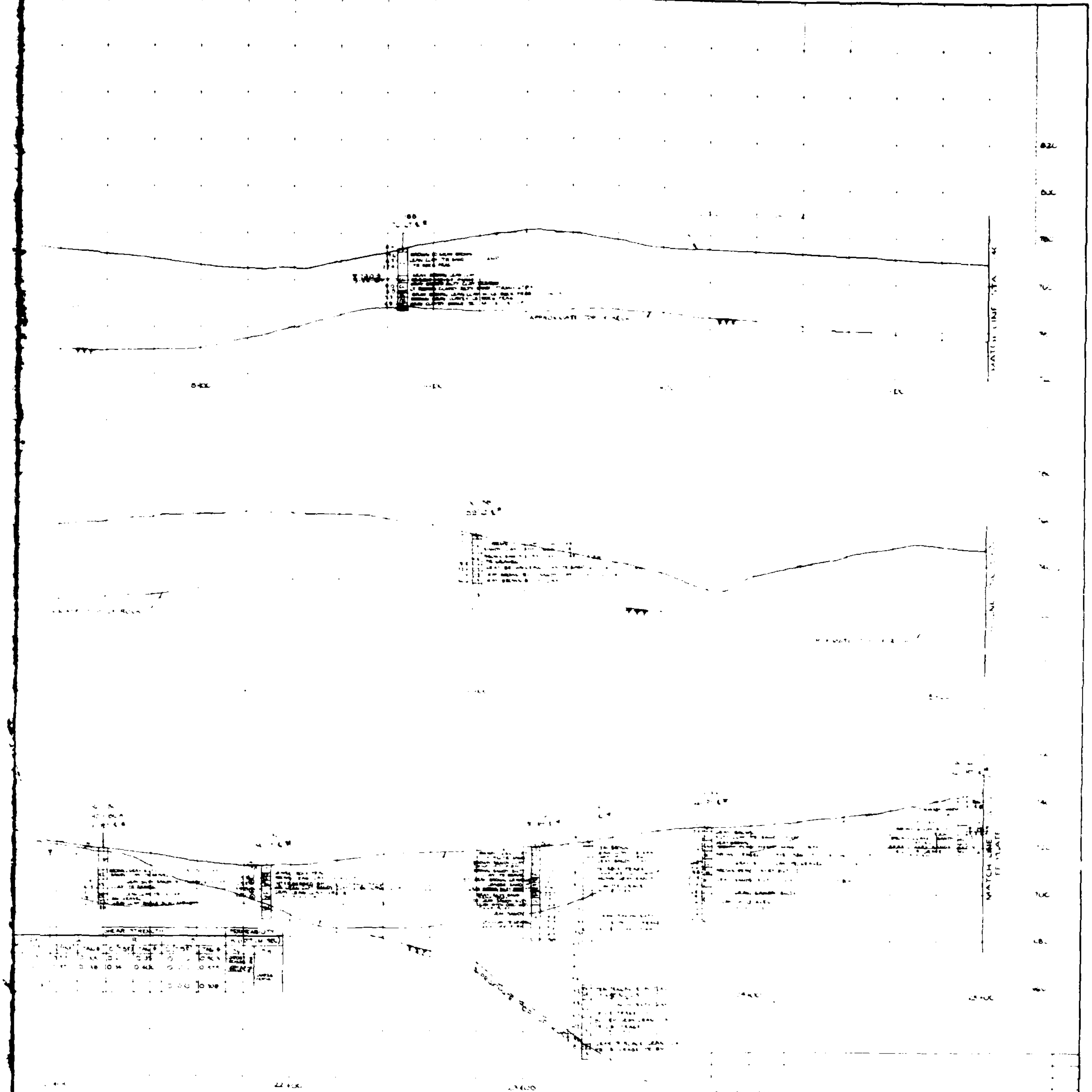
SCALE
DRAWING NUMBER

EXHIBIT 22

CORPS OF ENGINEERS



U. S. ARMY



* ALL HOLES PROJECTED ON CONTOURS

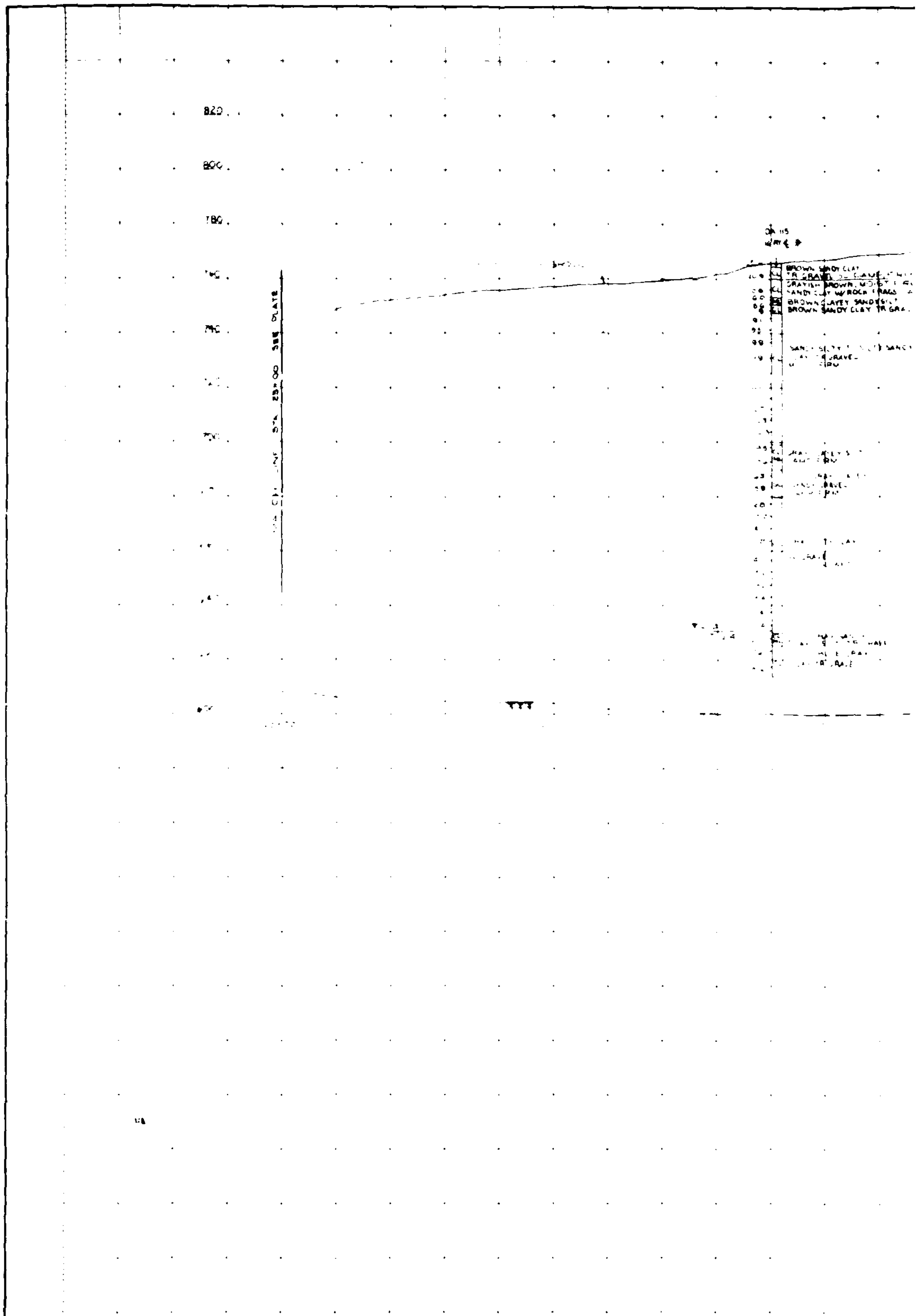
U. S. ARMY ENGINEER DISTRICT LOUISVILLE
CORPS OF ENGINEERS
LOUISVILLE, KENTUCKY

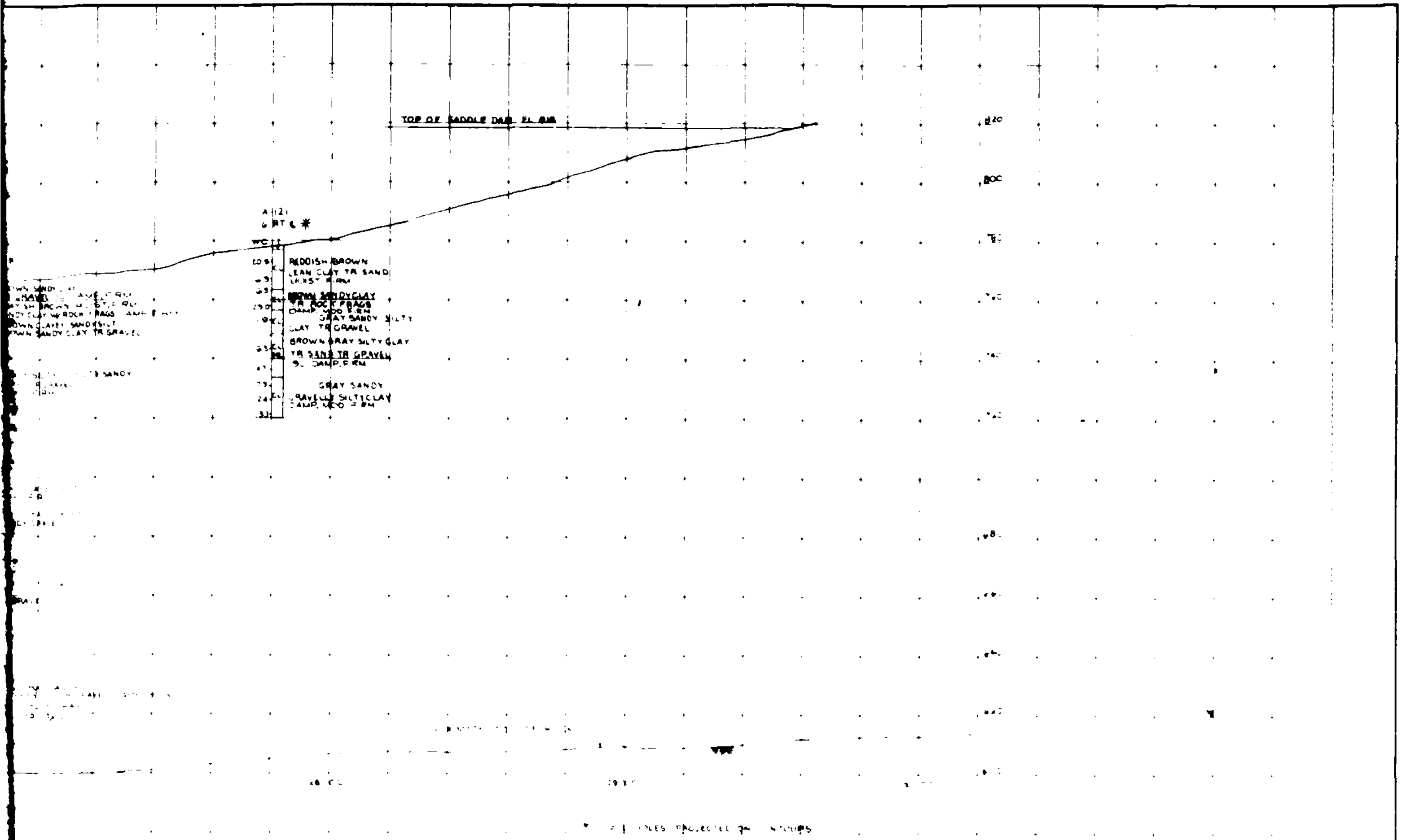
OHIO RIVER BASIN
EAST FORK LAKE
EAST FORK LITTLE MIAMI RIVER

GEOLOGIC PROFILE
SADDLE DAM

DRAWING NUMBER

:ORPS OF ENGINEERS





REVISION	DATE	DESCRIPTION	BY

U S ARMY ENGINEER DISTRICT, LOUISVILLE
CORPS OF ENGINEERS
LOUISVILLE, KENTUCKY

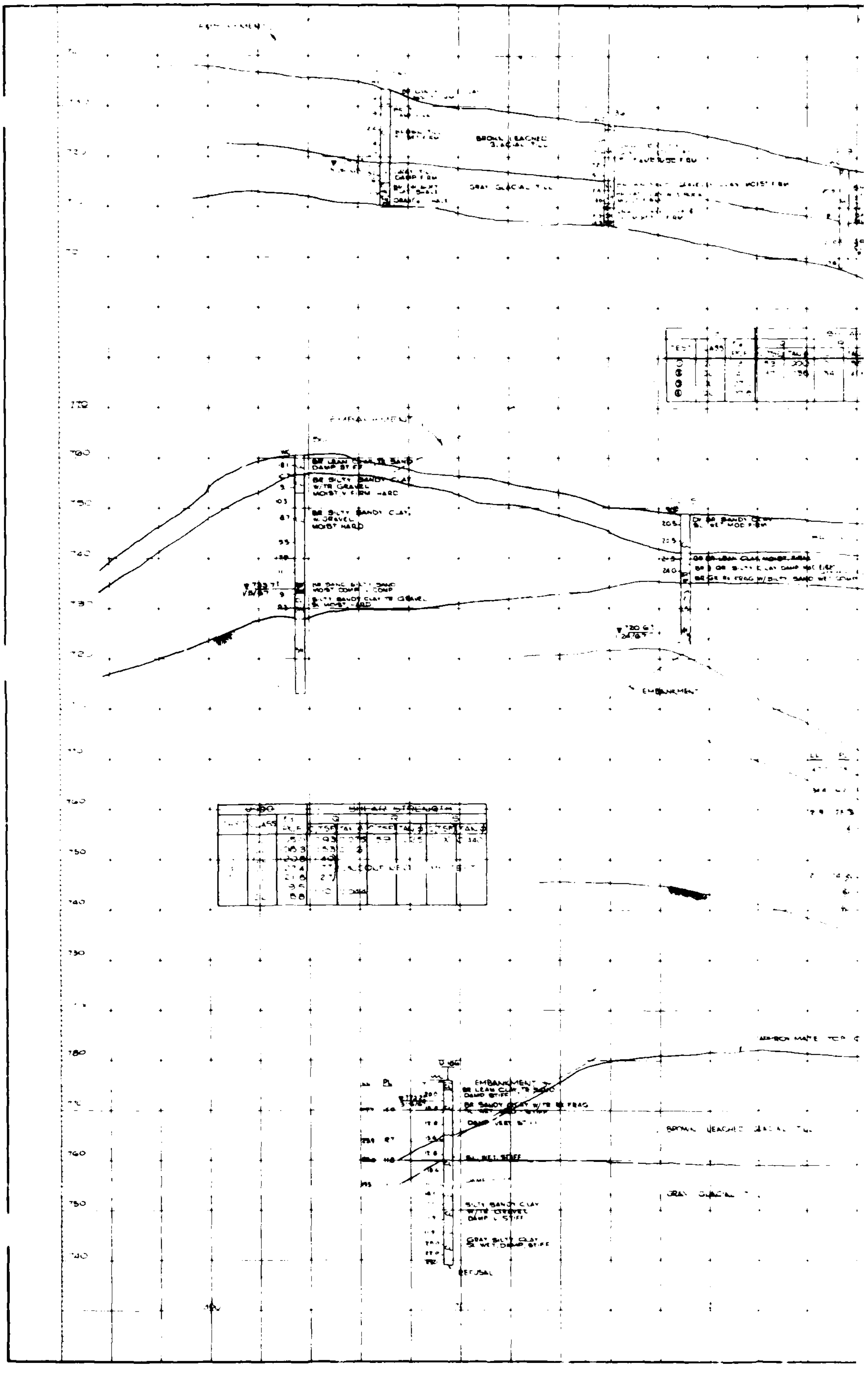
DRAWN: FBM
TRACED: JLF
CHECKED: EGM
SUBMITTED
SCALE

OHIO RIVER BASIN
EAST FORK LAKE
EAST FORK LITTLE MIAMI RIVER

GEOLOGIC PROFILE
SADDLE DAM
SHEET 2

DRAWING NUMBER

CORPS OF ENGINEERS



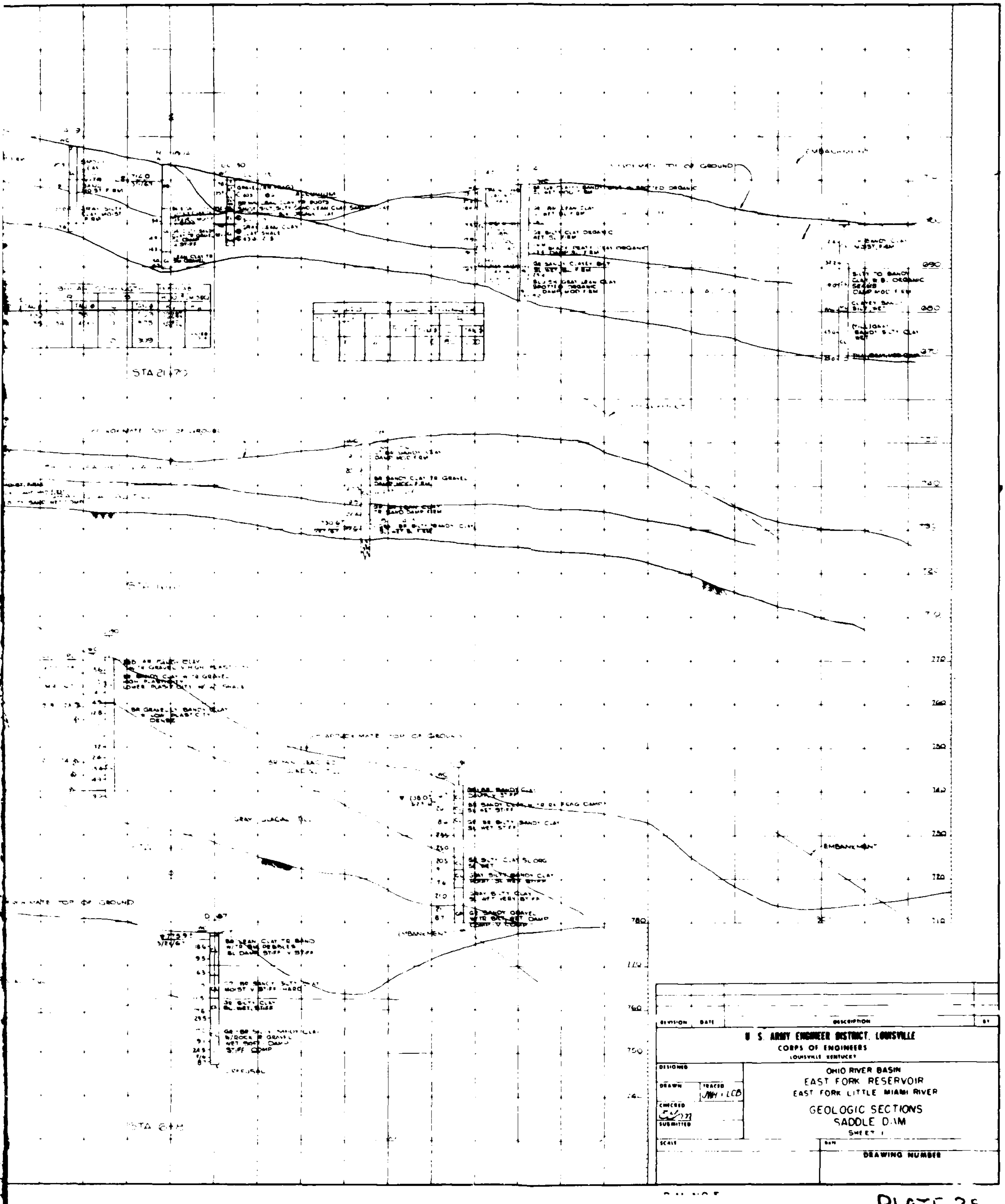
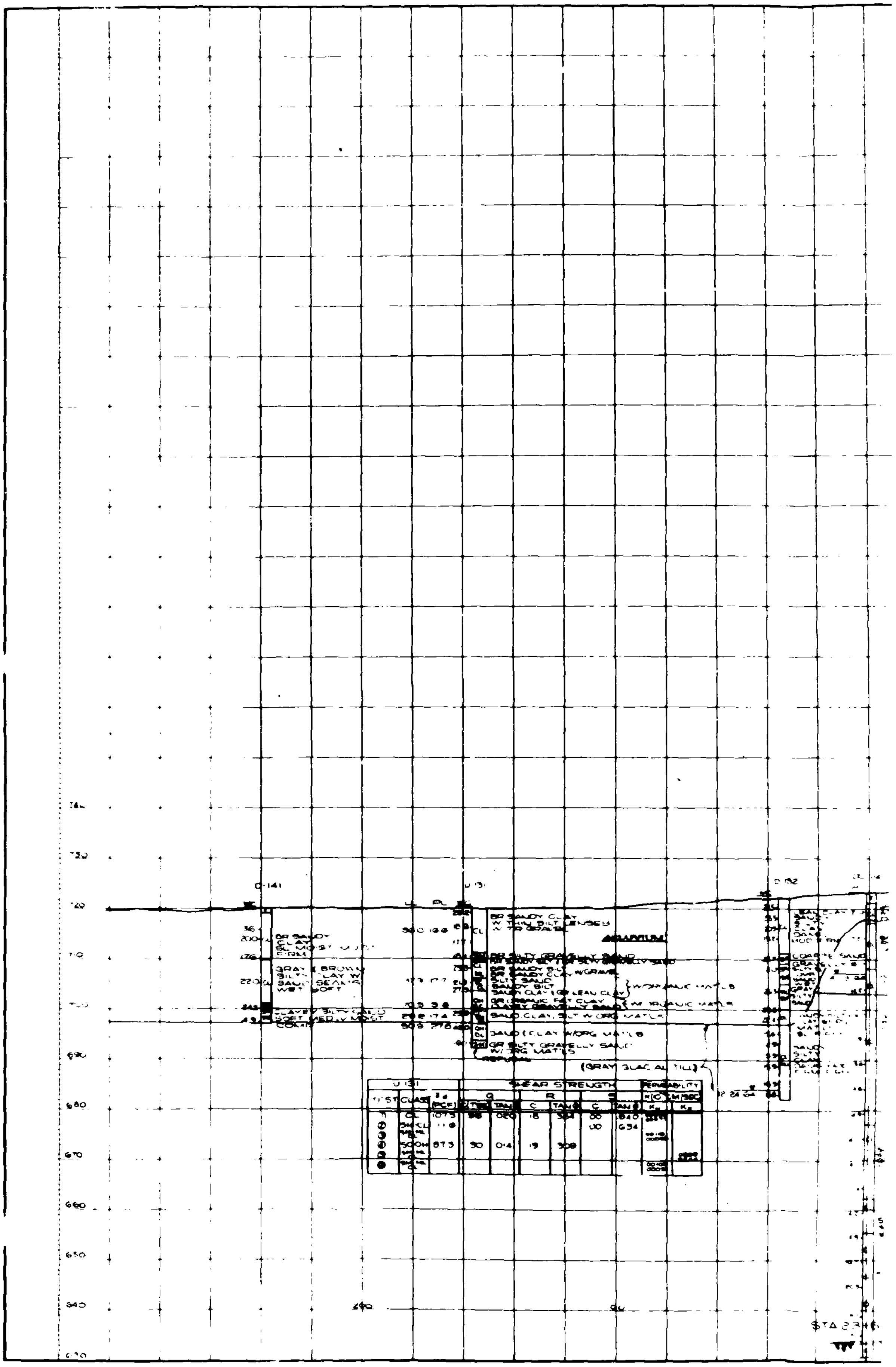
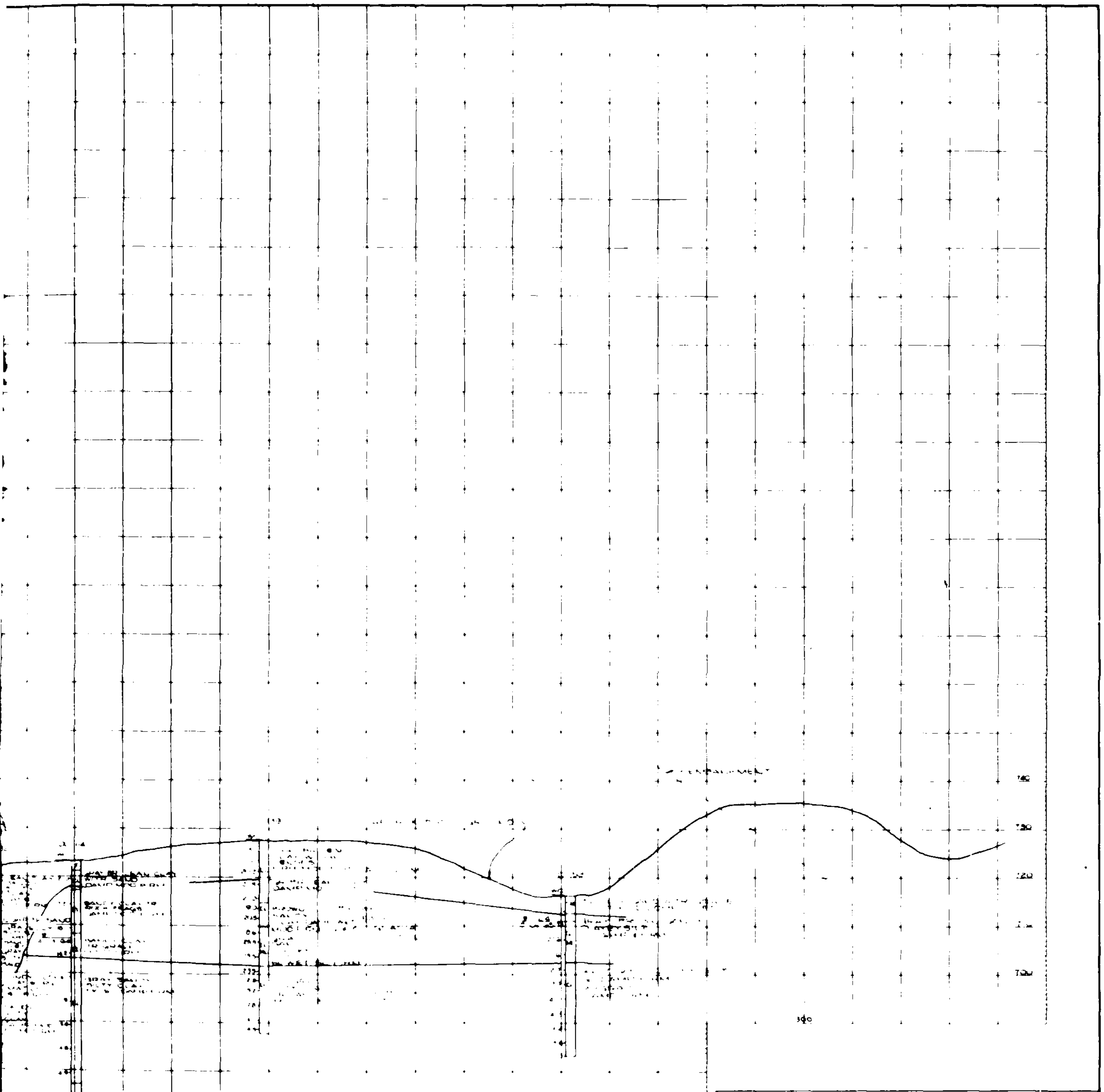

STA 21+70
APPROXIMATE TOP OF GROUND
EMBANKMENT
STA 6+14
U. S. ARMY ENGINEER DISTRICT, LOUISVILLE
CORPS OF ENGINEERS
LOUISVILLE, KENTUCKY
OHIO RIVER BASIN
EAST FORK RESERVOIR
EAST FORK LITTLE MIAMI RIVER
GEOLOGIC SECTIONS
SADDLE DAM
SHEET 1
REVISION
DATE
DESCRIPTION
BY
DESIGNED
DRAWN
TRACED
JWH + LCB
CHECKED
SUBMITTED
SCALE
DRAWING NUMBER

PLATE 25

CORPS OF ENGINEERS





REVISION	DATE	DESCRIPTION	BY

U. S. ARMY ENGINEER DISTRICT, LOUISVILLE
CORPS OF ENGINEERS
LOUISVILLE, KENTUCKY

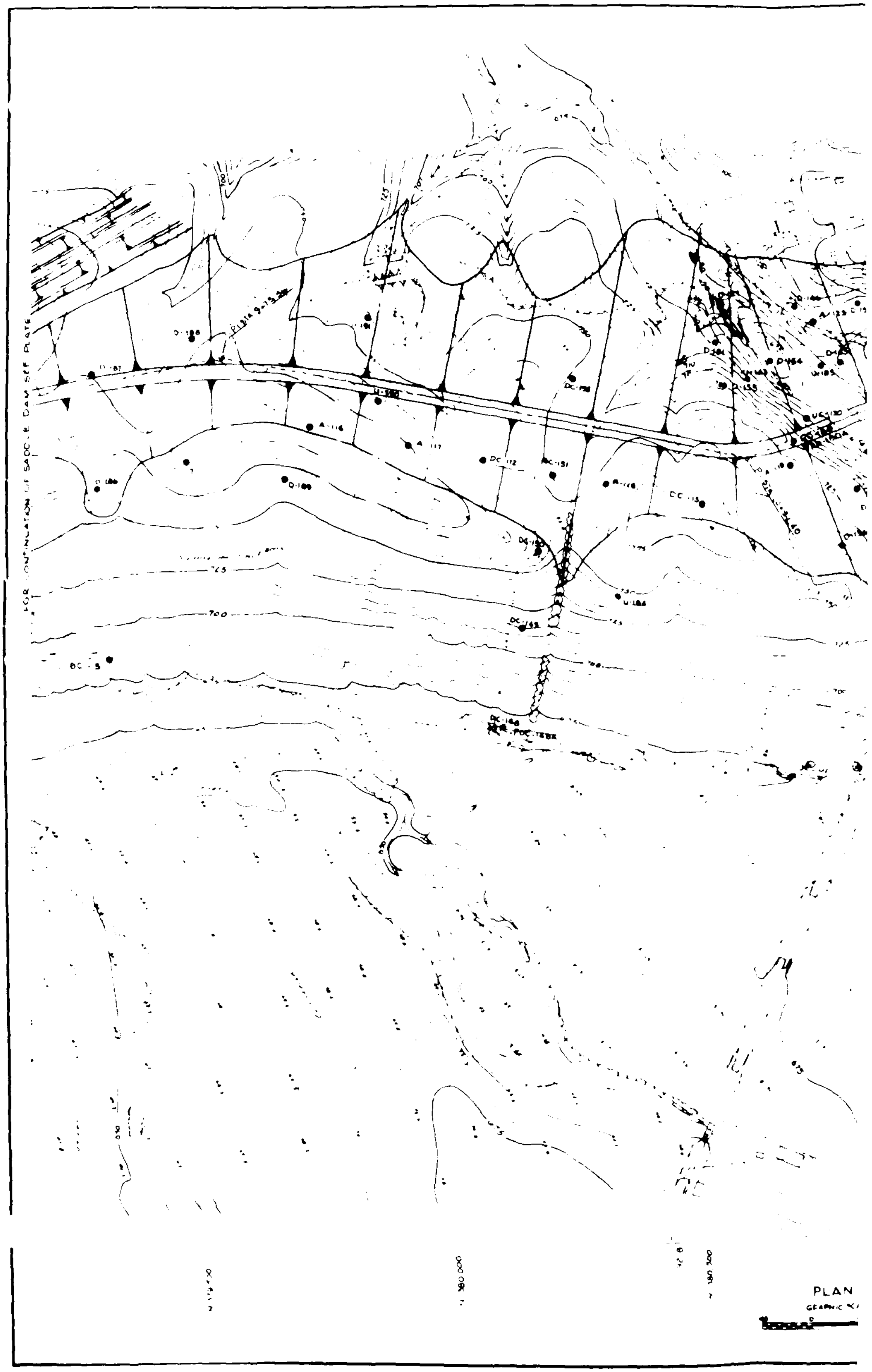
DESIGNED
DRAWN — TRACED
CHECKED
SUBMITTED
SCALE

OHIO RIVER BASIN
EAST FORK RESERVOIR
EAST FORK LITTLE MIAMI RIVER

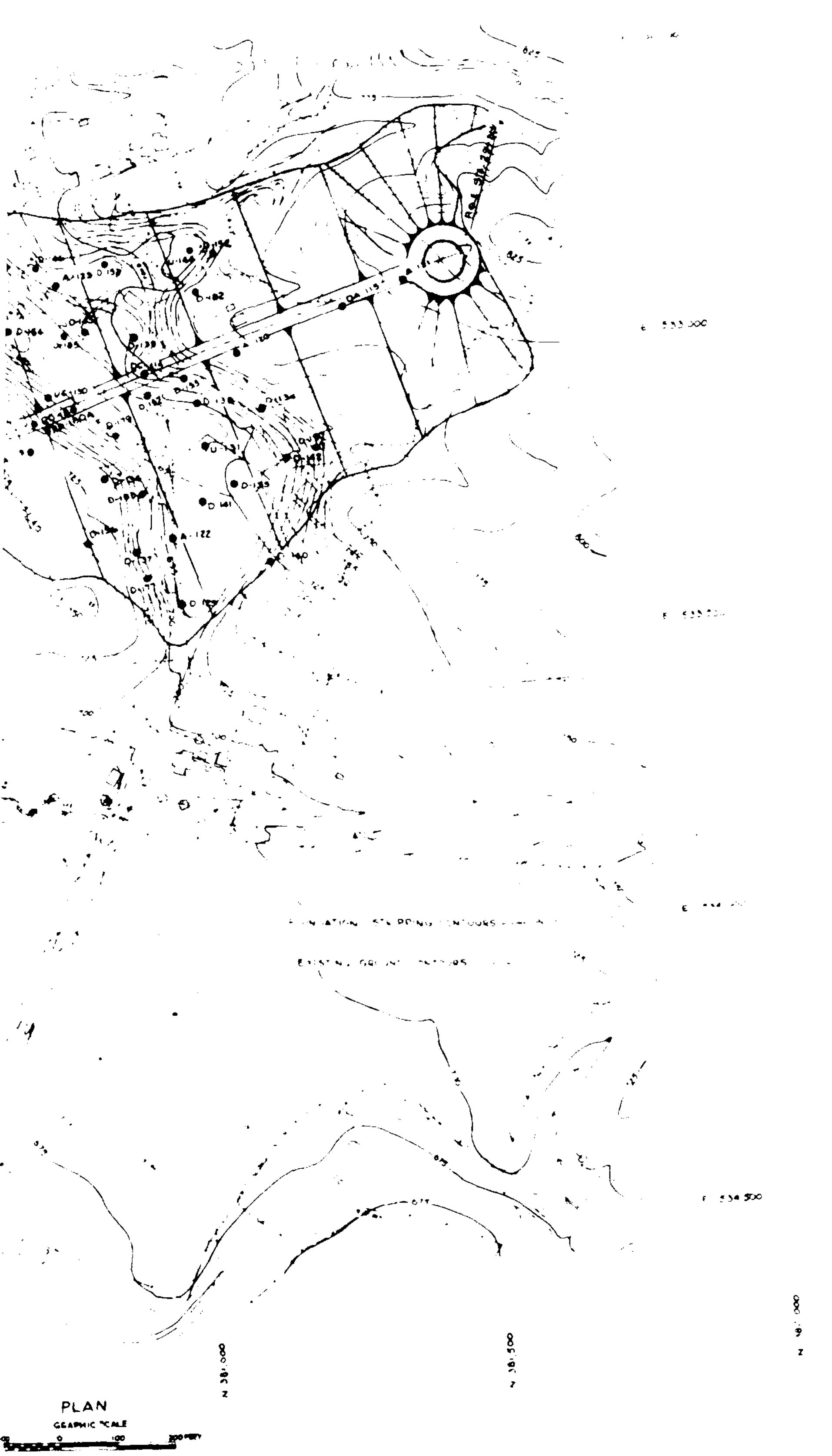
GEOLOGIC SECTIONS
SADDLE DAM

DATE
DRAWING NUMBER

CORPS OF ENGINEERS



U S ARMY



REVISION	DATE	DESCRIPTION	BY

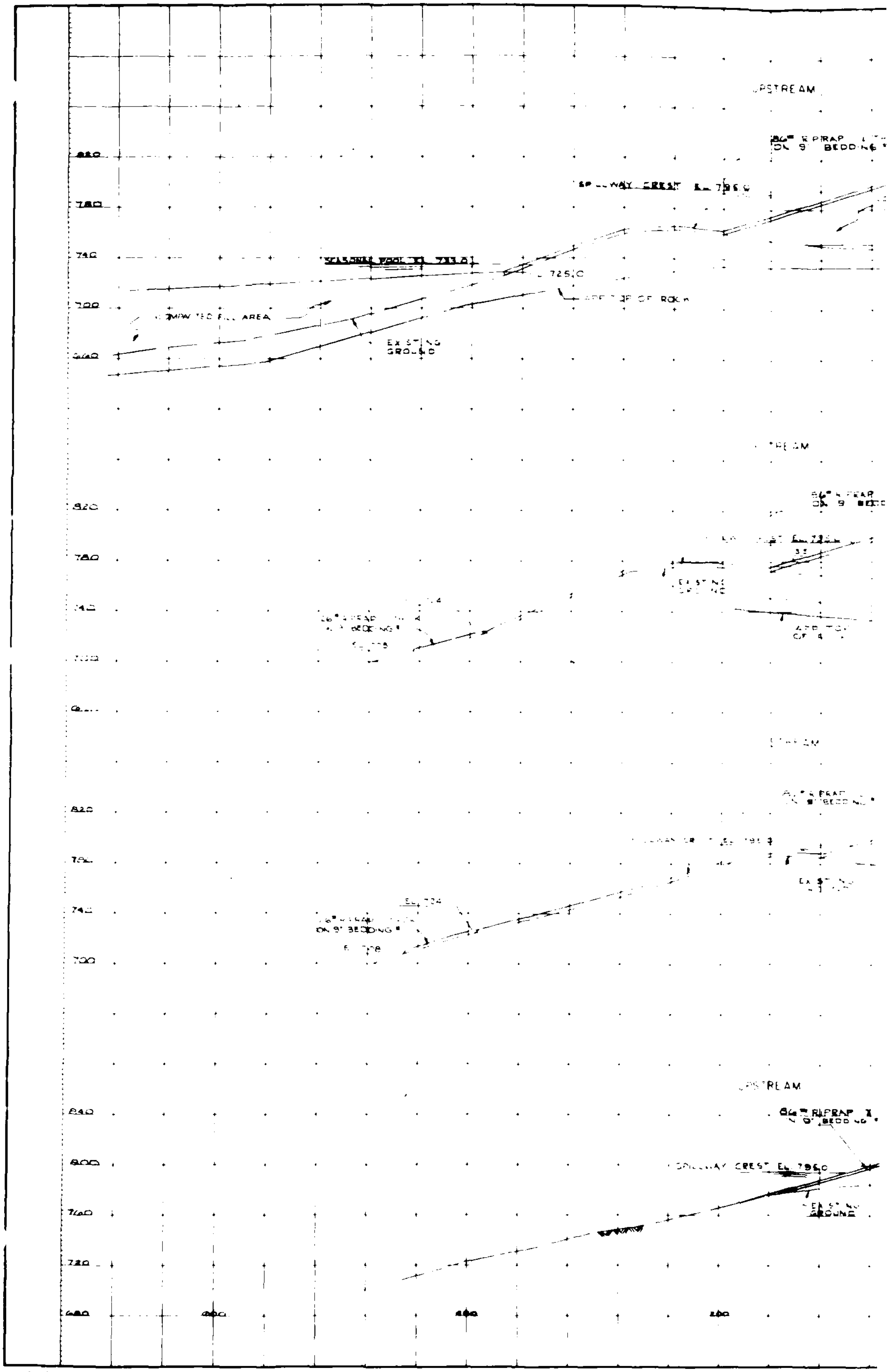
U S ARMY ENGINEER DISTRICT, LOUISVILLE
CORPS OF ENGINEERS
LOUISVILLE, KENTUCKY

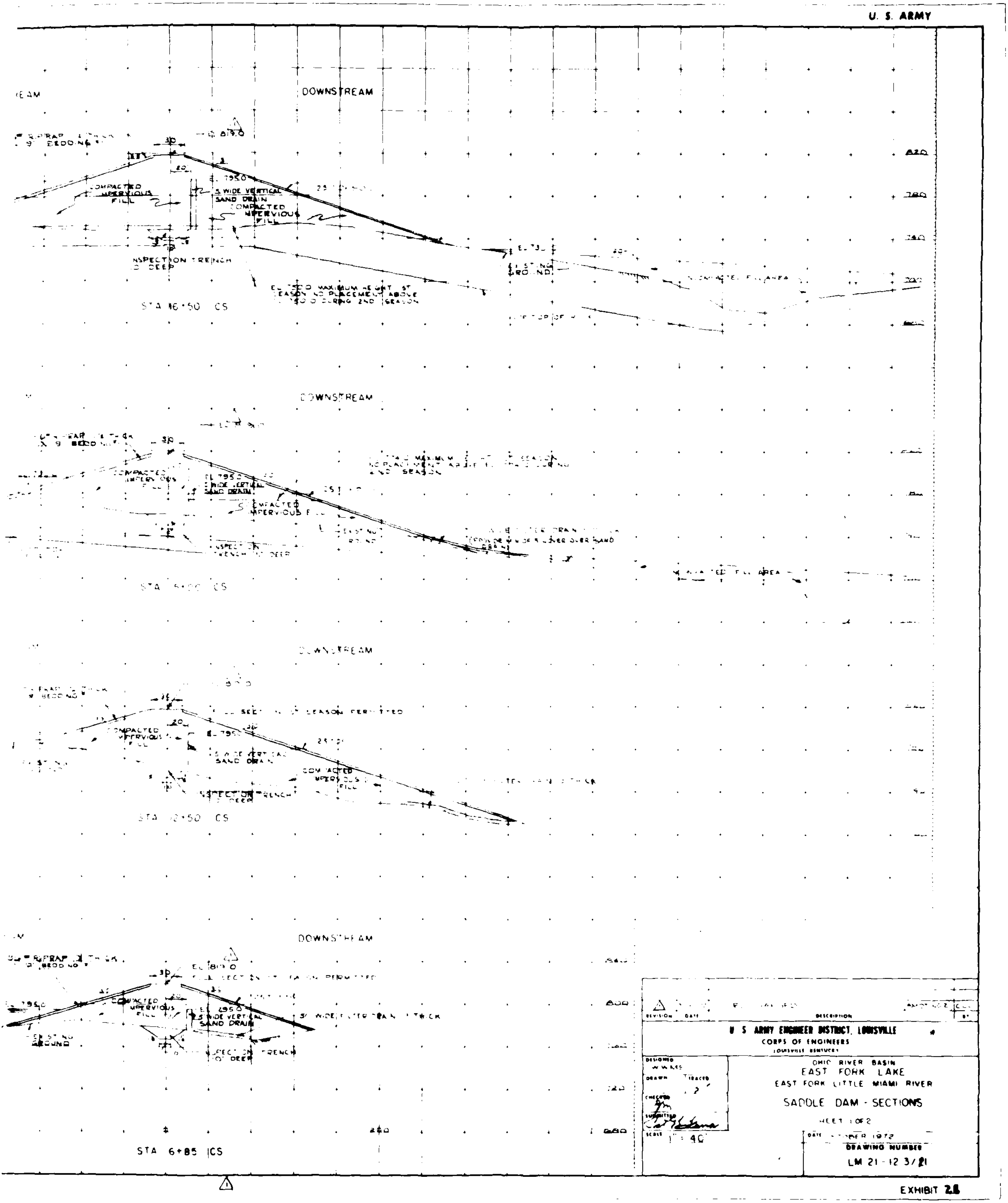
OHIO RIVER BASIN
EAST FORK RESERVOIR
EAST FORK LITTLE MIAMI RIVER

FOUNDATION STRIPPING PLAN
SADDLE DAM

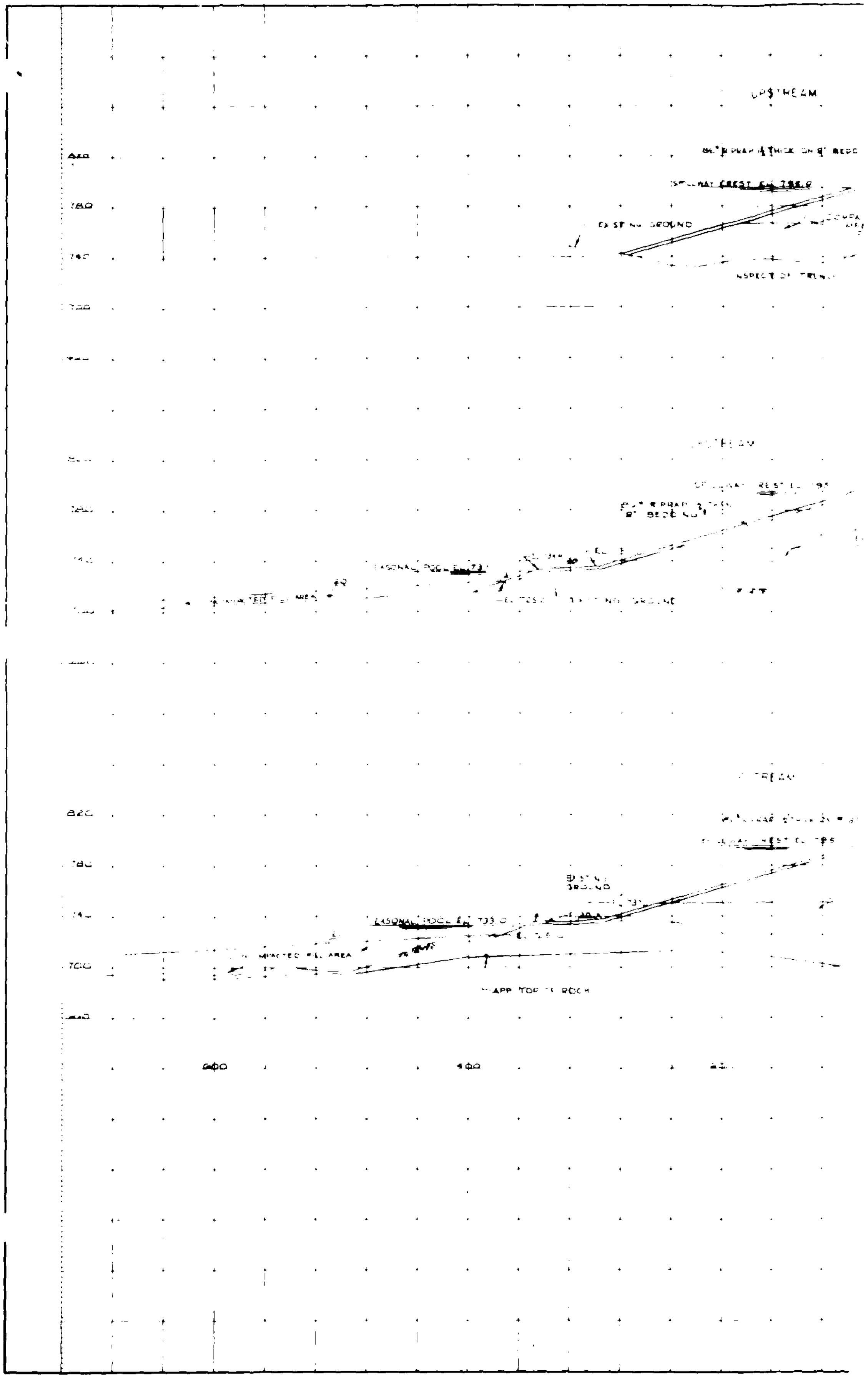
DESIGNED
DRAWN
TRACED
CHECKED
SUBMITTED
APPROVAL RECOMMENDED
ASST. CHIEF ENGINEERING DIV.
APPROVED
COL. CORPS OF ENGINEERS DISTRICT ENGINEER
DATE
1965
APPROVED
CHIEF ENGINEERING DIVISION
SCALE
DRAWING NUMBER

CORPS OF ENGINEERS

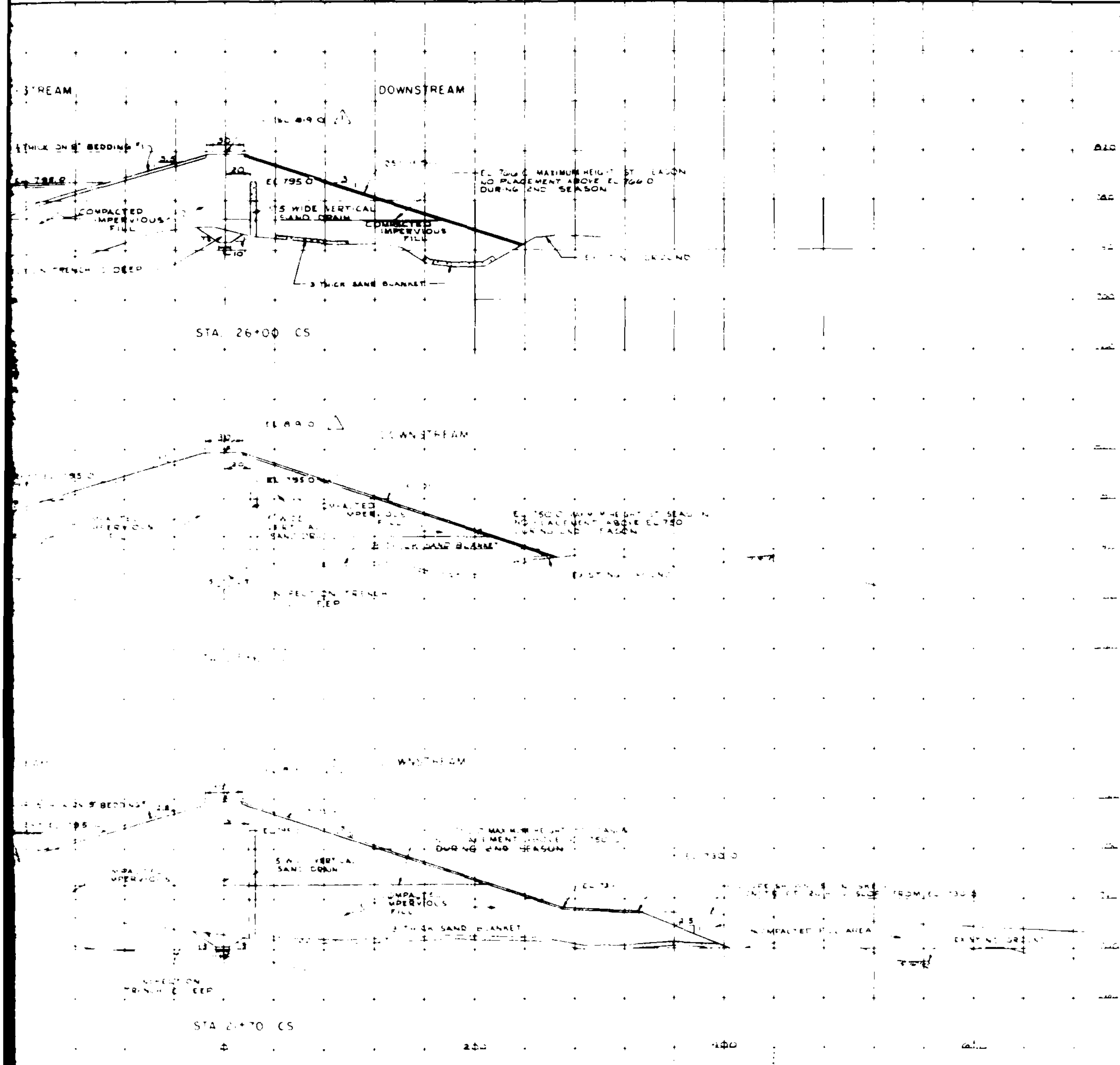



U. S. ARMY
DOWNSTREAM
COMPACTED IMPERVIOUS FILL
5' WIDE VERTICAL SAND DRAIN
INSPECTION TRENCH
STA 16+50 CS
DOWNSTREAM
DOWNSTREAM
STA 12+50 CS
DOWNSTREAM
STA 6+85 ICS
U S ARMY ENGINEER DISTRICT, LOUISVILLE
CORPS OF ENGINEERS
OHIO RIVER BASIN
EAST FORK LAKE
EAST FORK LITTLE MIAMI RIVER
SADDLE DAM - SECTIONS
DRAWING NUMBER

CORPS OF ENGINEERS



U. S. ARMY



REVISION	DATE	DESCRIPTION	BY
△		CHANGED	

U. S. ARMY ENGINEER DISTRICT, LOUISVILLE
CORPS OF ENGINEERS
LOUISVILLE KENTUCKY

OHIO RIVER BASIN
EAST FORK LAKE
EAST FORK LITTLE MIAMI RIVER

SADDLE DAM - SECTIONS

SHEET 2 OF 2

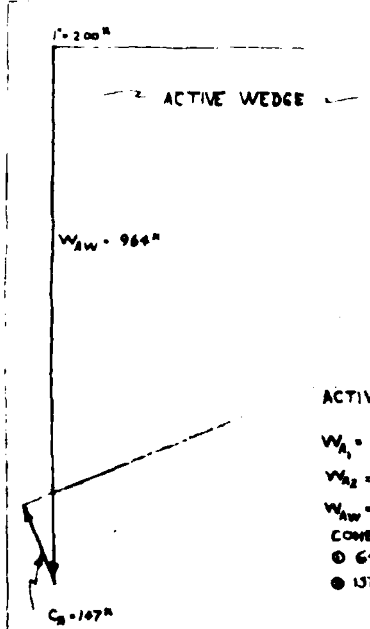
DESIGNED: DRAWN: TRACED: CHECKED: SUBMITTED:

SCALE 1" = 40'

DATE OCTOBER 1972

DRAWING NUMBER
LM 21-12.3/22

EXHIBIT 29



CALCULATIONS

ACTIVE WEDGE

$W_{A_1} = \frac{1}{2}(64)(36)(.127) = 146^k$

$W_{A_2} = [\frac{1}{2}(36+50)(72) + \frac{1}{2}(50)(127)](.130) = 818^k$

$W_{AW} = 146 + 818 = 964^k$

COHESION

① $64' \times 4\,KSF = 256^k$

② $137' \times 1.2\,KSF = \frac{164^k}{\Sigma = 420^k}$

$C_A = \frac{420}{2.86} = 147^k$

CENTRAL BLOCK

$W_{CB_1} = \frac{1}{2}(31)(177)(.127) = 345^k$

$W_{CB_2} = [\frac{1}{2}(23)(60) + \frac{1}{2}(60+29)(177)](.120) = 1100^k$

$W_{CB_3} = [\frac{1}{2}(177+105)(244)](.127) = 4420^k$

$W_{CB_4} = (105)(104)(.127) = 1390^k$

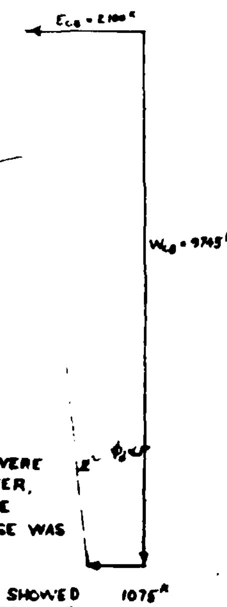
$W_{CB_5} = \frac{1}{2}(100)(391)(.127) = \frac{2490^k}{\Sigma = 9745^k}$

COHESION

① $767' \times 4\,KSF = 3068^k$

② $22' \times 1.2\,KSF \quad \frac{27^k}{\Sigma = 3095^k}$

$C_B = \frac{3095^k}{2.85} = 1075^k$

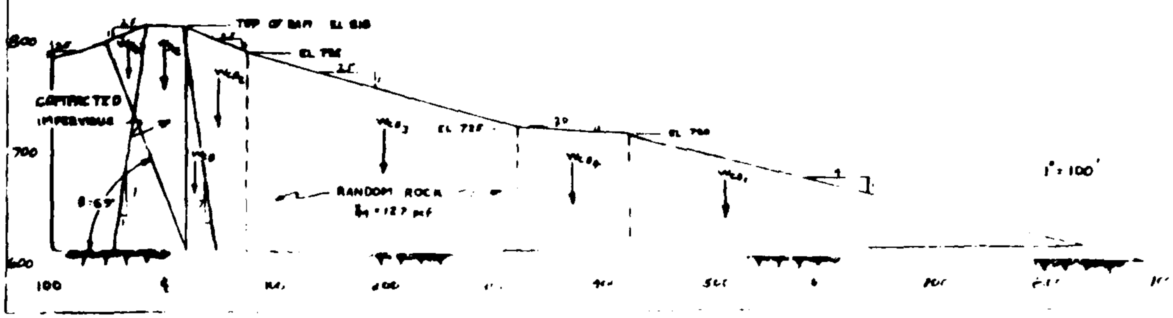


ADOPTED DESIGN VALUES				
MATERIAL	γ (PCF)		STRENGTH	
	MOIST	SAT	TAN φ	C (TSF)
COMP. IMPERV.	130	133	0	.6
RANDOM ROCK	127	139	.306	2.0

NOTES:

1. SLOPE STABILITY COMPUTATIONS WERE MADE WITH A G.E. 425 COMPUTER, USING PROGRAM 41-K2-H202. THE STABILITY OF THE CRITICAL WEDGE WAS CHECKED MANUALLY.

2. A SEARCH BY THE COMPUTER SHOWED THE MINIMUM FACTOR OF SAFETY TO BE 2.85, θ = 690', AND VRTP TO BE 20'



MAIN DAM

EAST FORK LAKE
STABILITY ANALYSIS
WEDGE METHOD
END OF CONSTRUCTION

SUPPLEMENT 2 DM #5 PLATE 30

PLATE 30

BY WWMcC DATE .... SUBJECT East Fork Reservoir SHEET NO. 2 OF ....
CHKD. BY .... DATE .... Saddle Dam Stability Analysis JOB NO ....
End of Construction Q Strengths 400x55 EOC

NOTES:

1. Slope stability computations were made with an IBM 360 electronic computer using program no. 41-K2-H205. The stability of the critical circle was checked with the manual computations shown on sheet no 3

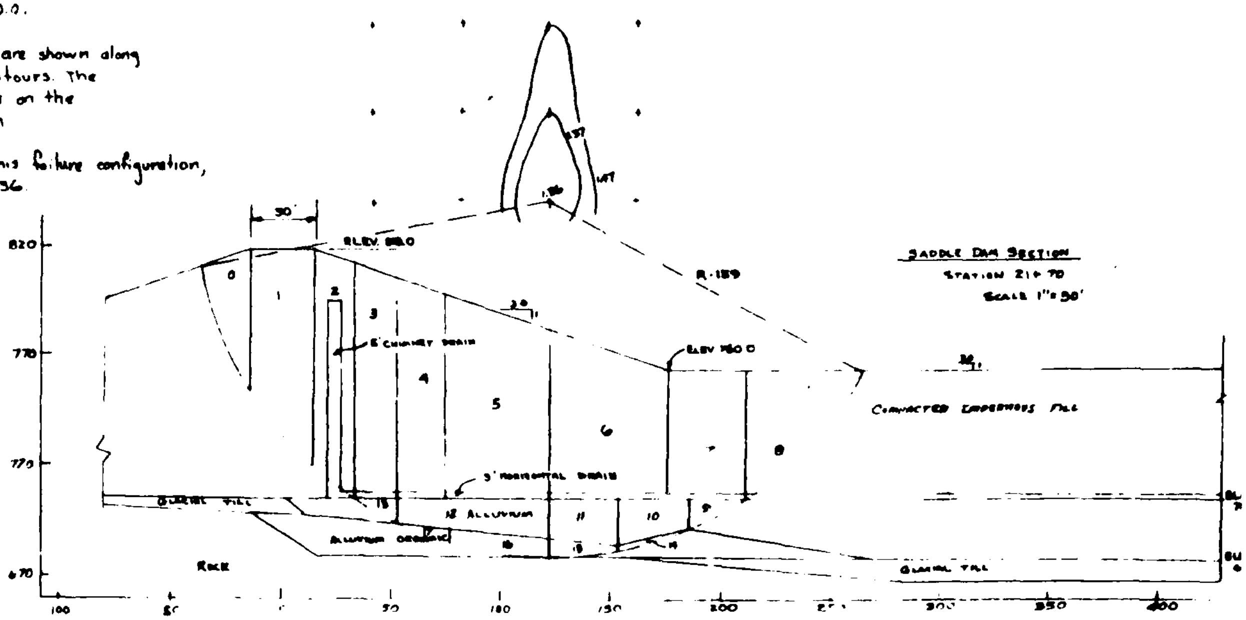
2. A search by the computer showed the most critical configuration to be a circle tangent to a firm base (glacial till & rock) at elevation 680.0.

3. Centers of base circles are shown along with "factor of safety" contours. The critical circle is shown on the embankment cross section

4. The factor of safety for this failure configuration, using "Q" strengths, was 1.36.

5. It is noted that the location of the center of the critical circle is not bounded in the Y direction. This presentation was made as an illustration to show the huge magnitude of berm size that would be needed if no excavation or controlled loading were carried out. Therefore, further investigation was not felt needed.

ADOPTED DESIGN VALUES					
MATERIAL	γ (pcf)			"Q" STRENGTHS	
	MOIST	SAT	SUB	TAN φ	c (tsf)
EMBANKMENT	133	–	–	0.0	1.1
ALLUVIUM	126	–	–	0.0	0.86
ALLUVIUM ORGANIC	119	–	–	0.0	0.28



East Fork Reservoir - Saddle Dam
SUPPLEMENT 2 DM #5 PLATE 31
STATION 21+70 - DOWNSTREAM
STABILITY ANALYSIS - EOC - 400x55 B

PLATE 31

BY WWM DATE ______ SUBJECT EAST FORK RESERVOIR SHEET NO 6 OF ____
CHKD. BY ______ DATE ______ SADDLE DAM STABILITY ANAL JOB NO ______
End of Construction Q Strengths GC 224 BEN41

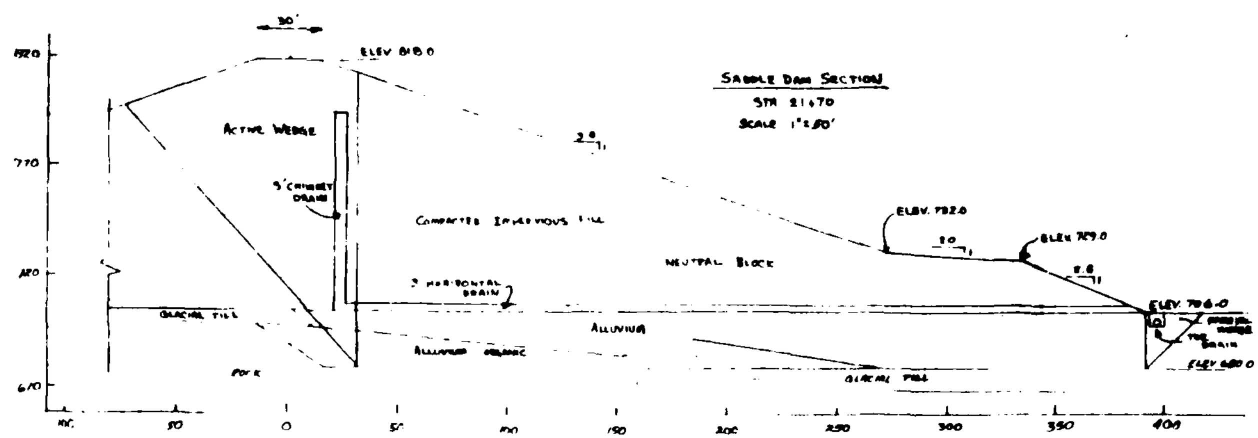
NOTES:

1. Slope stability computations were made with an IBM 360 electronic computer using program no 41-K2-H202. The stability of the critical wedge was checked with the manual computations shown on sheets no 7-10.

2. A search by the computer showed the most critical wedge to be the one tangent to a firm base (glacial till & rock), at the inclination shown, at elevation 660.0 (est. ±5).

3. The manual computations shown on sheets no 7-10, were based on a 2.5 to 1 slope from Elev 818 to Elev. 795. Computer results were based on this slope also.

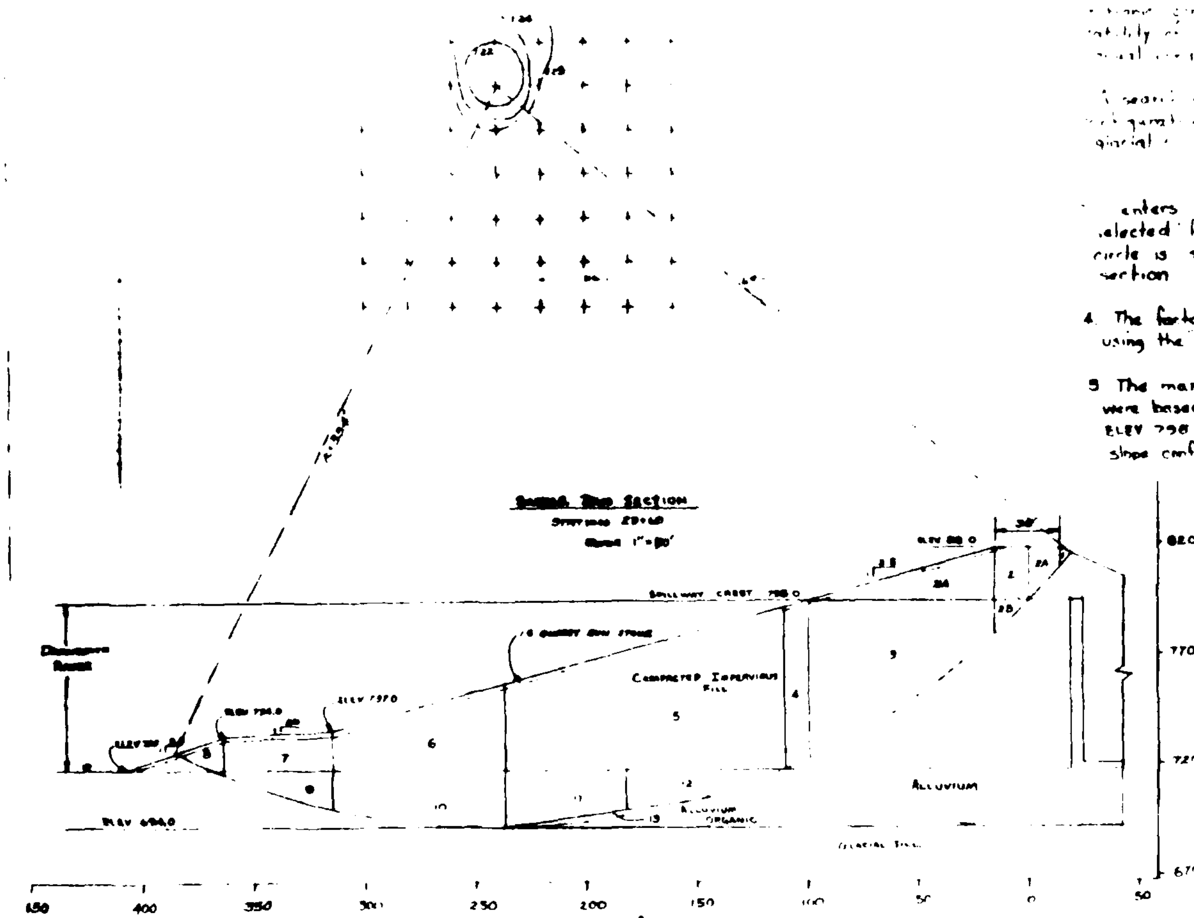
Adopted Design Values					
Material	γ (pcf)			Q Strengths	
	Moist	Sat	Sub	Tan φ	c (ksf)
Embankment	135	-	-	0.0	1.1
Alluvium	126	-	-	0.0	0.86
Alluvium Organic	119	-	-	0.0	0.78



EAST FORK RESERVOIR - SADDLE DAM
SUPPLEMENT 2 DM #5 PLATE 32
STATION 21+70 DOWNSTREAM
STABILITY ANALYSIS END OF CONST

PLATE 32

BY WWM DATE ... SUBJECT ... Reservoir ... SHEET NO 11 OF
CKD BY ... DATE ... Saddle ... Stability Anal. ... JOB NO
... Sudden ... R Strength ... 45' x 5' Berm



... The computations were made with an IBM 360 ... computer ... The stability of the critical circle ... checked with the manual computations ... sheet no. 12.

A search by the ... showed the most critical configuration to be a circle tangent to a firm base ... at elevation ...

Centers of base circles are shown along with selected factor of safety contours. The critical circle is shown on the embankment cross section.

4. The factor of safety for this failure configuration, using the R strengths, was 1.21.

5. The manual computations, shown on sheet no. 12, were based on a 2.8 to 1 slope from ELEV. 810 to ELEV 790. Computer results were based on this slope configuration also.

ADOPTED DESIGN VALUES					
MATERIAL	γ (pcf)			"R" STRENGTHS	
	Moist	Sat.	Sub.	Tan φ	c(ksf)
EMBANKMENT	133.0	136.0	74.5	.510	0.4
ALLUVIUM	123.0	128.0	[illegible]	.303	0.21
ALLUVIUM ORGANIC	114.0	114.0	51.5	.283	0.37

East Fork Reservoir - Saddle Dam
SUPPLEMENT 2 DM #5 PLATE 33
Station 23+60 - Upstream
45' x 5' Berm
Stability Analysis - Sudden Drawdown

PLATE 33

BY WWM DATE ..... SUBJECT East Fork Reservoir SHEET NO. 13 OF ..
CHKD. BY ..... DATE ..... Saddle ... Stability Anal. JOB NO .....
End of Construction Upstream 'Q' strength ...

NOTES:

1. Slope stability computations were made with an IBM 360 electronic computer using program no 41-K2-H202. The stability of the critical wedge was checked with the manual computations shown on sheets no. 14 & 15.

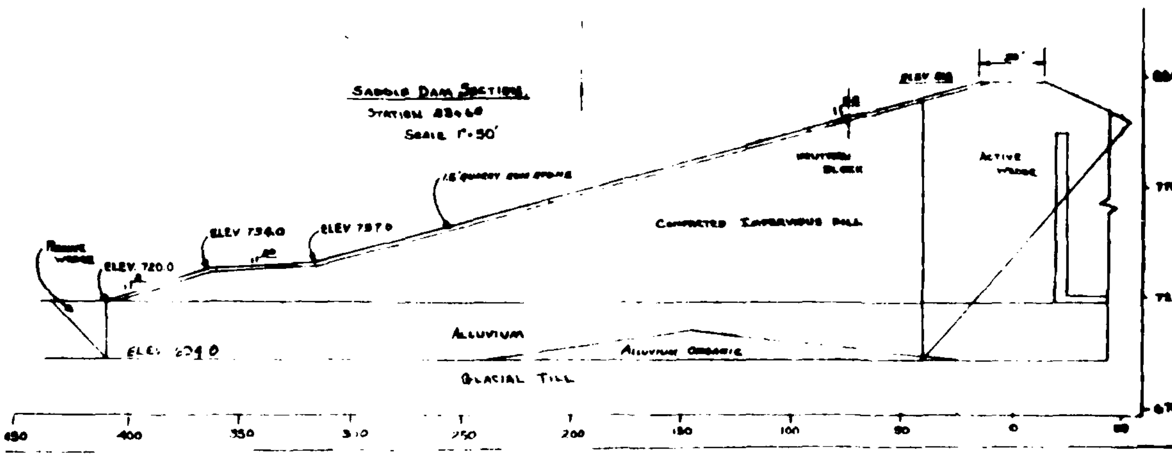
2. A search by the computer showed the most critical configuration to be a wedge tangent to a firm base (glacial till) at elevation 694.7.

3. The factor of safety for this configuration, using Q strengths, was FS = 1.07

4. The manual computations shown on sheets 14 & 15 were based on a 2.5 to 1 slope from Elev 810.0 to Elev 795. Computer results were based on this slope also.

MATERIAL	γ pcf			"Q" STRENGTHS	
	moist	sat	sub.	Tan ϕ	c (tsf)
Embankment	135.0	–	–	0.0	.41
Alluvium	120.0	–	–	0.0	0.20
Alluvium Organic	119.0	–	–	0.0	0.10

ADOPTED DESIGN VALUES



East Fork Reservoir Saddle Dam
SUPPLEMENT 2 DM #5 PLATE 34
Station 83+60 - Upstream
Stability Analysis - End of Const.

PLATE 34

BY WWMC	DATE	SUBJECT East Fork Reservoir	SHEET NO. 4 OF 12
CHKD. BY	DATE	Saddle Lake Sta. 21+70	JOB NO.
		Steady Seepage Avg. R&S strengths 60 x 24 berm	

NOTES:

1. Slope Stability computations were made with an IBM 360 electronic computer using program no 41-K2-H203. The stability of the critical circle was checked with the manual computations shown on sheet no 5.

2. A search by the computer showed the most critical configuration to be a circle tangent to a firm base (glacial till) at elevation 680.0.

3. Centers of base circles are shown along with factor of safety contours. The critical circle is shown on the embankment cross section.

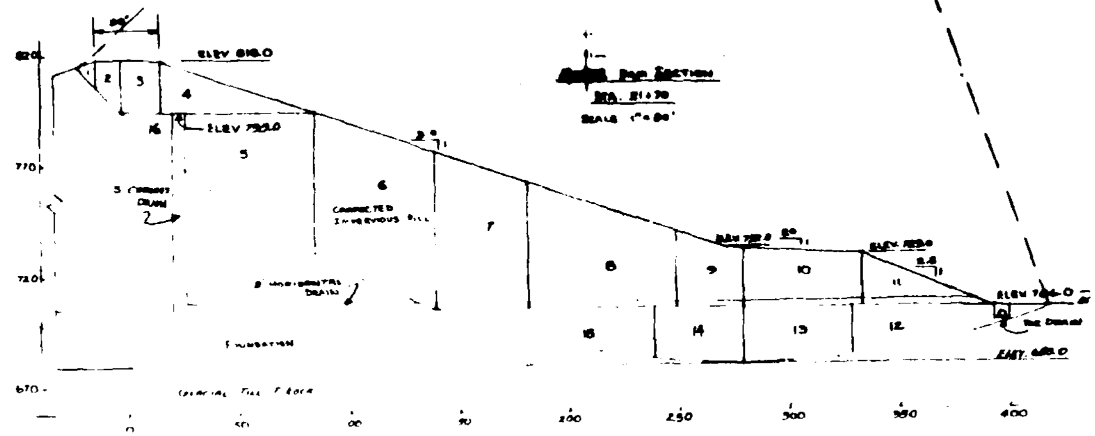
4. The factor of safety for this failure configuration, using an average of the R&S strengths, was 1.55

5. Composite strengths were used for foundation R&S values. The foundation should act as a unified system on a long term basis. The failure plane was chosen as the base of the alluvium & the alluvium organic. Any developed failure plane would most likely occure at the intersection of this system and the glacial till.

6. Average values of tan ϕ & c (obtained from R&S tests) were used in the analysis. This was done as an attempt to recognize the gain in strength of the foundation as drainage occurs during consolidation.

7. The manual computations, shown on sheet no. 5, were based on a 2.5 to 1 slope from ELEV 818 to ELEV. 798. Computer results were based on this slope configuration also.

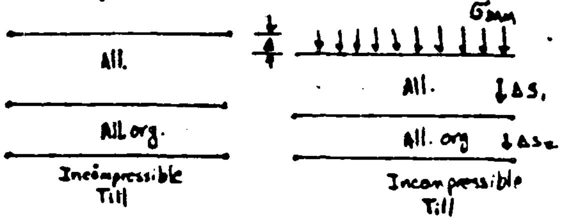
ADOPTED DESIGN VALUES									
Material	γ (PCF)			R strength		S strength		Avg. of R&S	
	Moist	Sat	Sub	tan ϕ	c	tan ϕ	c	tan ϕ	c
Embankment	133.0	134.0	71.5	310	0.4	50	0.0	.405	0.2
Alluvium	123R / 1235	121R / 1235	58.5 / 60.5	303	0.21	.445	0.0		
Alluvium Organic	114R / 1205	114R / 1205	51.5R / 57.5	.35	0.23	.541	0.0		
Composite of Alluvium & Alluvium Org.	115R / 1225	118R / 1225	55R / 59.5	309	.22	[illegible]	0.0	.401	.11



EAST FORK RESERVOIR - SADDLE DAM
STATION 21+70 - DOWNSTREAM
STABILITY ANALYSIS - STEADY SEEPAGE
WWMC 60'x24' BERM JUNE 1969

BY WWM DATE 5-1-69 SUBJECT Consolidation Analysis SHEET NO. [illegible] OF [illegible]
CHKD. BY [illegible] DATE 5-26-69 East Fork Res. JOB NO. % Consolidation
Saddle Dam vs. Time Curves

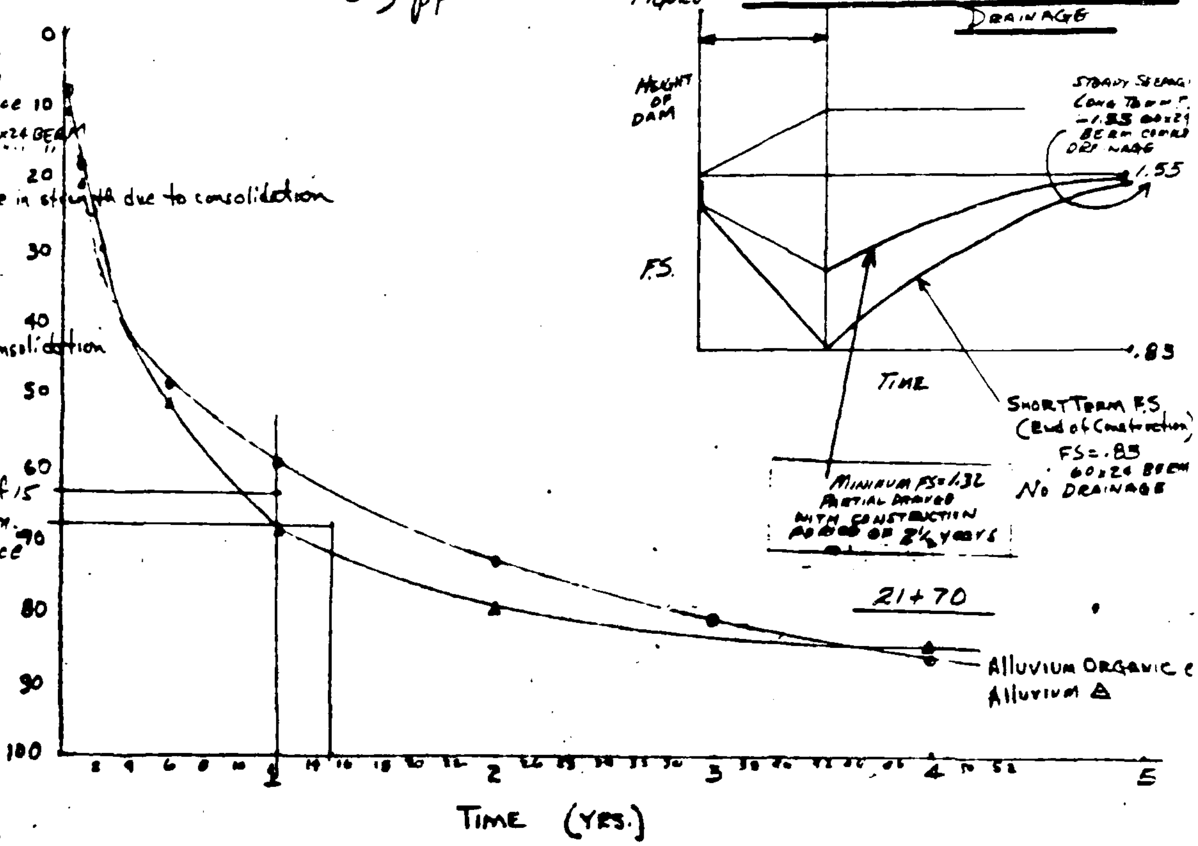
Construction Rate and Its Effect on FS End of Construction



$\Delta = \Delta S_1 + \Delta S_2$

Since failure will occur in the alluvium organic, consideration should be given to this layer and its gain in strength as the consolidation process occurs. It is realized that the alluvium will gain in strength correspondenly with the alluvium organic. Therefore both % consolidation vs time curves will be drawn and an avg. curve will be used for calculation purposes. This approach may vary somewhat depending upon the critical section used for the various cases of factor of safety determination.
The method used in constructing the settlement curves for various loading periods is stated in Taylor's "Fundamentals of Soil Mechanics", pp 290-292

Figure 2. FS. vs Time for Various Degrees of Drainage



– Try 2 years –
Load is on an average of one year
∴ 62% consolidation will have taken place
1.55 FS. SS 60x24 Berm
.83 FS. EOC " "
.72
x.62 % increase in strength due to consolidation
144
432
.4464

.83 FS.
+ .44 gain due to consolidation
1.27 NG

Try 2½ years %
load is on an av. of 15 months ∴ 68% con. will have taken place
1.55
.83
.72
x.68
576
432
.4896

.83
.49
1.32 ok

SUPPLEMENT 2 DM #5 PLATE 36

Figure 1 – % Con. vs Time Curve

BY [illegible] DATE 9/4/69 SUBJECT EAST FORK RESERVOIR SHEET NO 3 OF 5
CHKD. BY ...... DATE ...... SADDLE DAM STABILITY ANAL. JOB NO ......
END OF CONSTRUCTION Q STRENGTH 60X24 BERM

NOTES.

1 Slope stability computations were made with an IBM 360 electronic computer using program no 41-K2-H202.

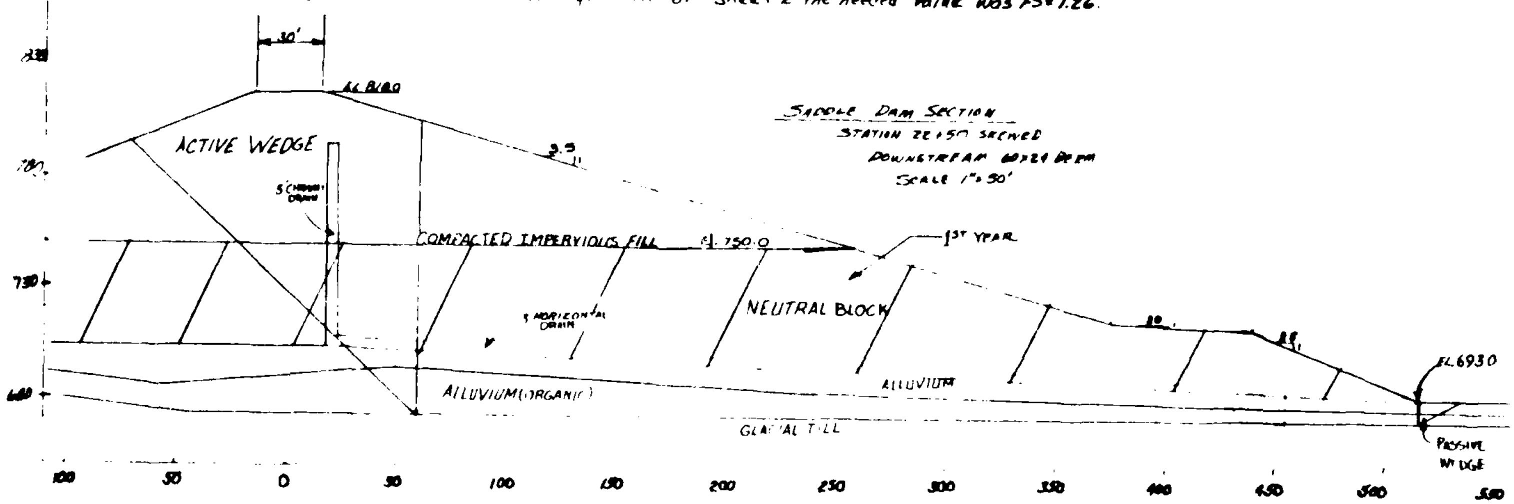
2 A search by the computer showed the most critical wedge to be the one tangent to a firm base (glacial till & rock) at the inclination shown, at elevation 684.0 (F.S. = .08)

3 With a 60'x24' Beam and a construction rate of a minimum of three years the value for FS is 1.31.

4 With a 60'x24' Berm, the maximum elevation safely obtainable is 750.0', where FS = 1.32

ADOPTED DESIGN VALUES					
MATERIAL	δ (PCF)			"Q" STRENGTHS	
	MOIST	SAT	SUB	TAN φ	C (tsf)
EMBANKMENT	133	-	-	0.0	1.1
ALLUVIUM	126	-	-	0.0	0.86
ALLUVIUM ORGANIC	119	-	-	0.0	0.28

5 Using same cross section, the value of FS when embankment is at 755.0' is FS = 1.23.
As shown in calculation of equation on sheet 2 the needed value was FS = 1.26.



EAST FORK RESERVOIR SADDLE DAM
SUPPLEMENT 2 DM5 PLATE 37
STATION 22+50 SKEWED DOWNSTREAM
STABILITY ANALYSIS END OF CONST.

BY W.H.M. DATE 8/11/69 SUBJECT East Fork Reservoir SHEET NO 4 OF 5
CHKD. BY ____ DATE ____ Saddle Dam / Skewed Section / JOB NO ____
End of Construction / 23+50 / Upstream

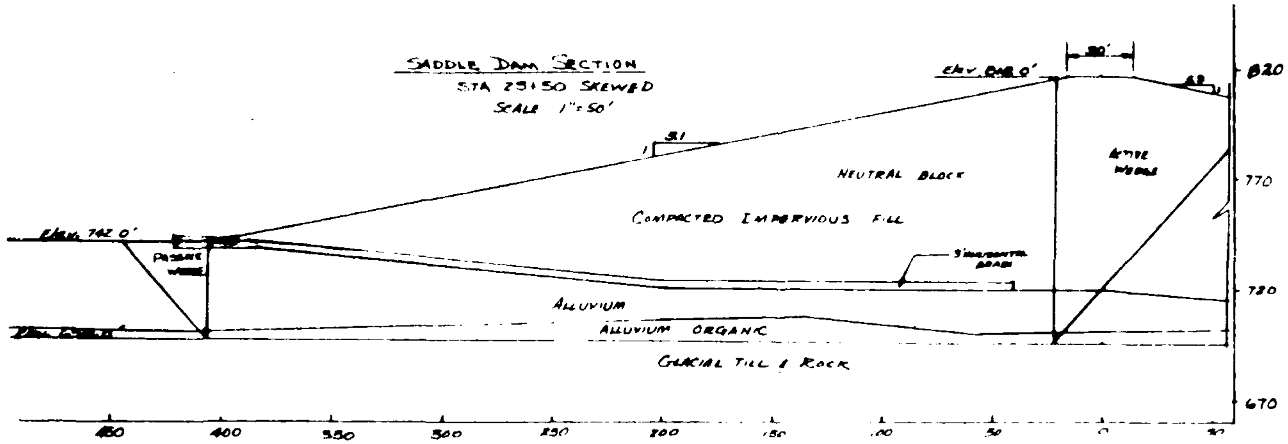
NOTES: 1. Slope stability computations were made with an IBM 360 electronic computer using program no 41-K2-H202

2. A search by the computer showed the critical configuration to be a wedge tangent to a firm base of elevation 690'.

3. The factor of safety for this configuration, using Q strengths, was, FS = 1.03

4. The upstream end of construction factor of safety, using the same construction rate as downstream, will be >1.3 (End of construction downstream FS >1.3), upstream has lower fill height & steeper slope. As consolidation occurs, during the three year construction period, the increase in strength, as shown in the downstream analysis, will also occur upstream, providing adequate safety.

ADOPTED DESIGN VALUES					
Material	γ pcf			Q STRENGTH	
	moist	sat	sub	Tan φ	c (tsf)
Embankment	1[illegible].0	–	–	0.0	1.1
Alluvium	126.0	–	–	0.0	0.06
Alluvium Organic	119.0	–	–	0.0	0.26



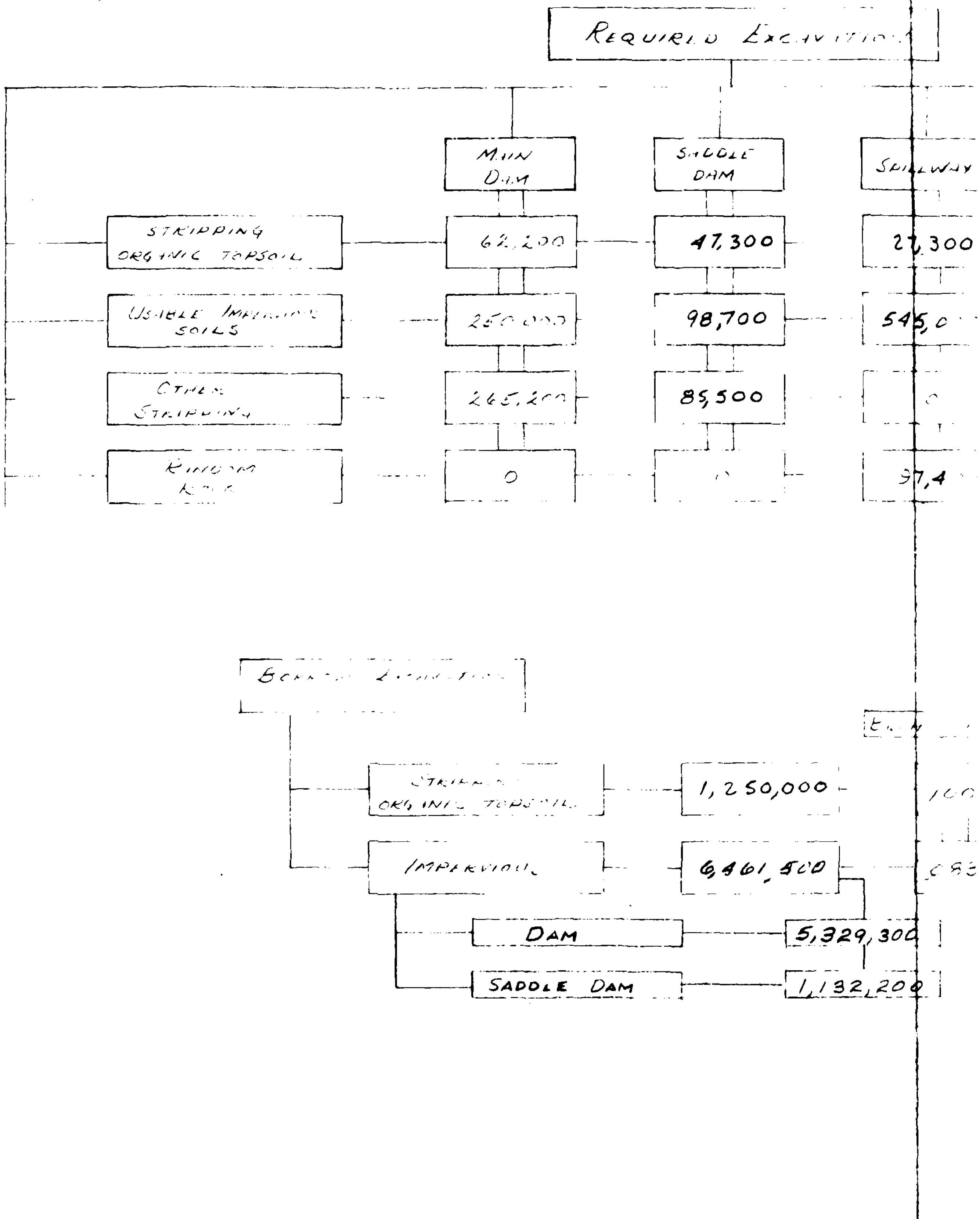
EAST FORK RESERVOIR
SADDLE DAM
STABILITY ANALYSIS
END OF CONSTRUCTION
23+50 SKEWED

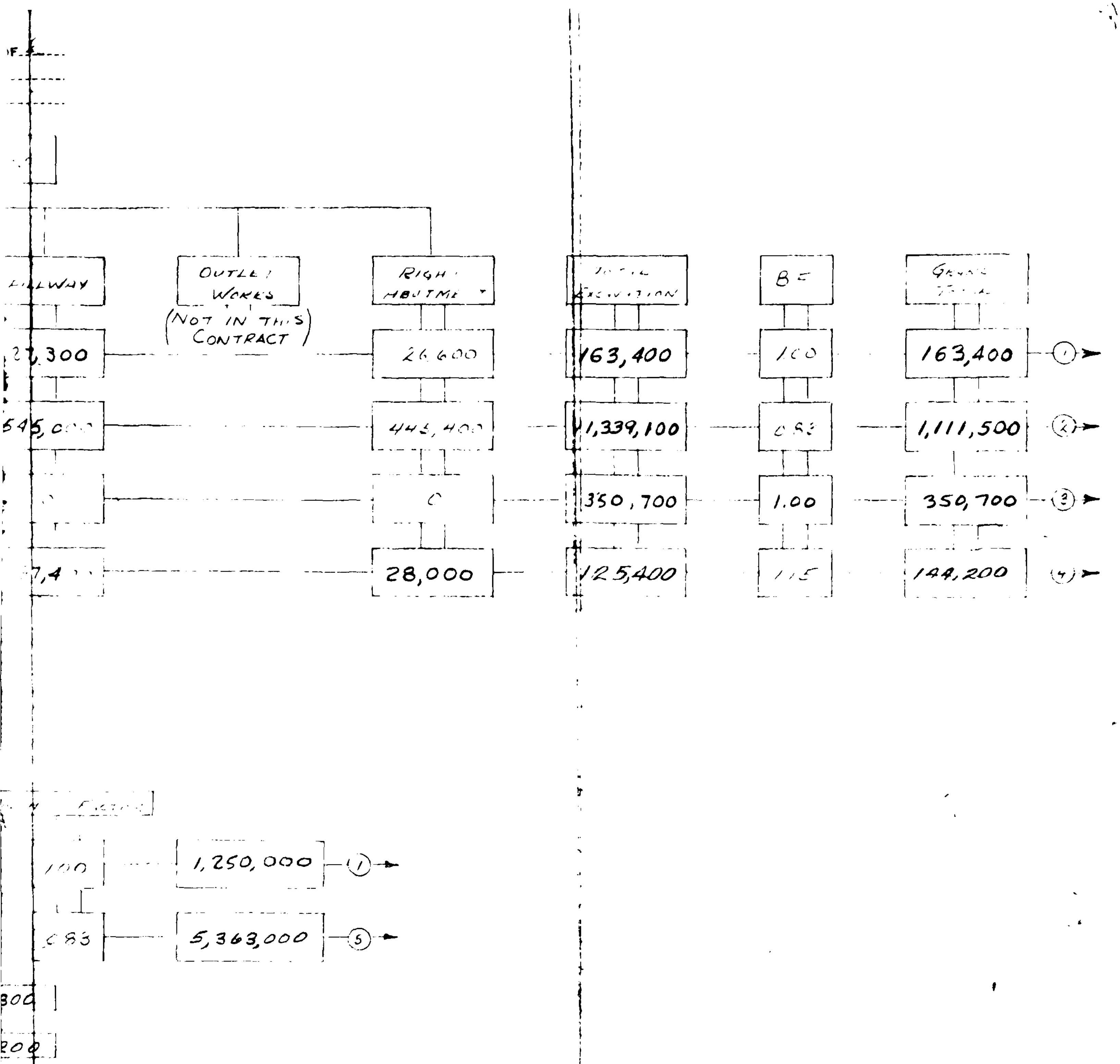
SUPPLEMENT 2 DM #5 PLATE 38

BY GMM DATE 8/2/65 SUBJECT EAST FORK RESERVOIR SHEET NO. 1 OF 1

CHKD. BY ______ DATE ______ JOB NO. ______

MATERIALS USAGE CHART



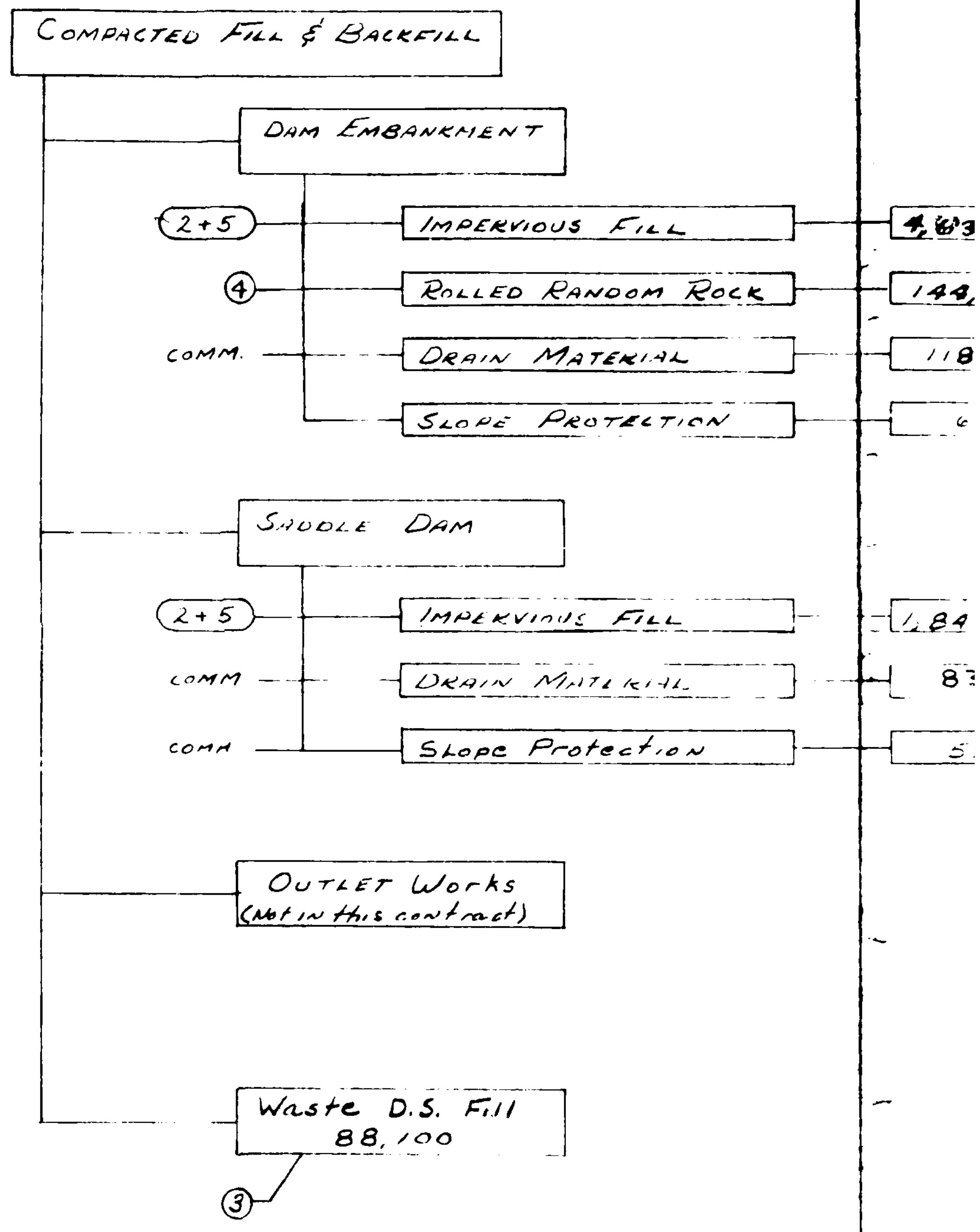

OUTLET WORKES
(NOT IN THIS CONTRACT)
RIGHT ABUTMENT
TOTAL EXCAVATION
B F
26,600
163,400
1.00
163,400
443,400
1,339,100
0.83
1,111,500
350,700
1.00
350,700
28,000
125,400
144,200
1,250,000
5,363,000

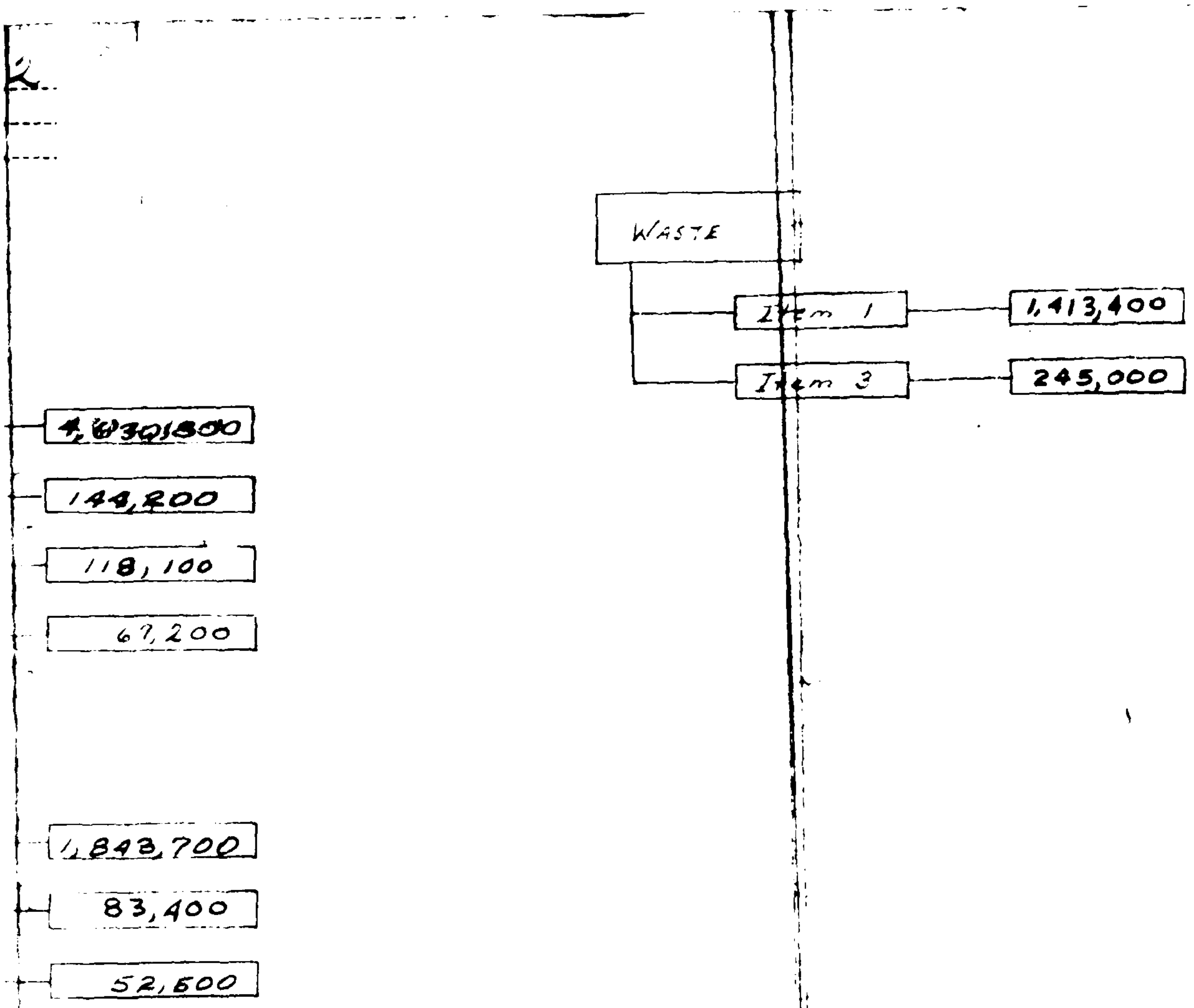
D.M. 5

BY ___ DATE 8/2/65 SUBJECT EAST FORK RESERVOIR SHEET NO. 2 OF 2

CHKD. BY ___ DATE ___ OHIO JOB NO. ___

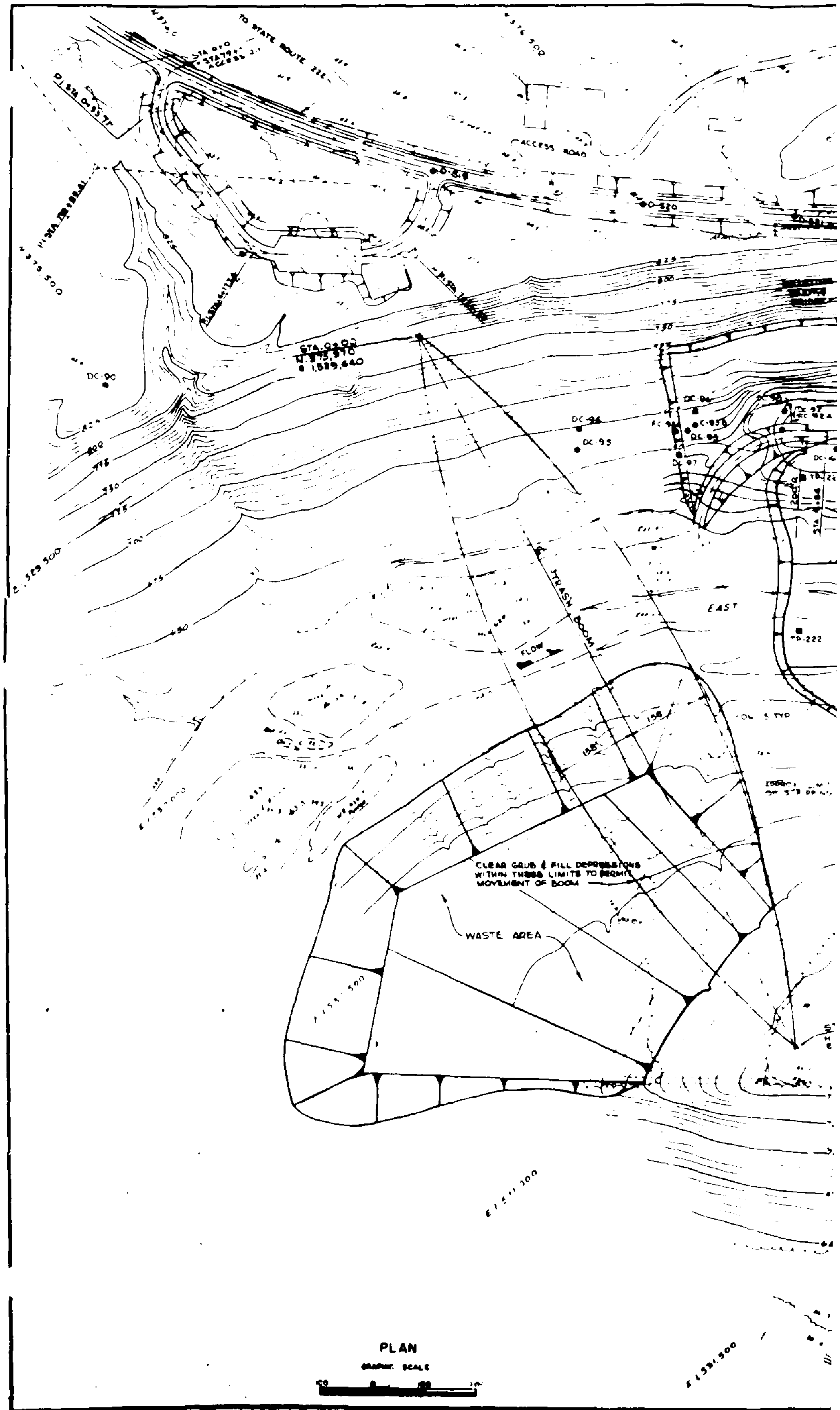
MATERIALS USAGE CHART

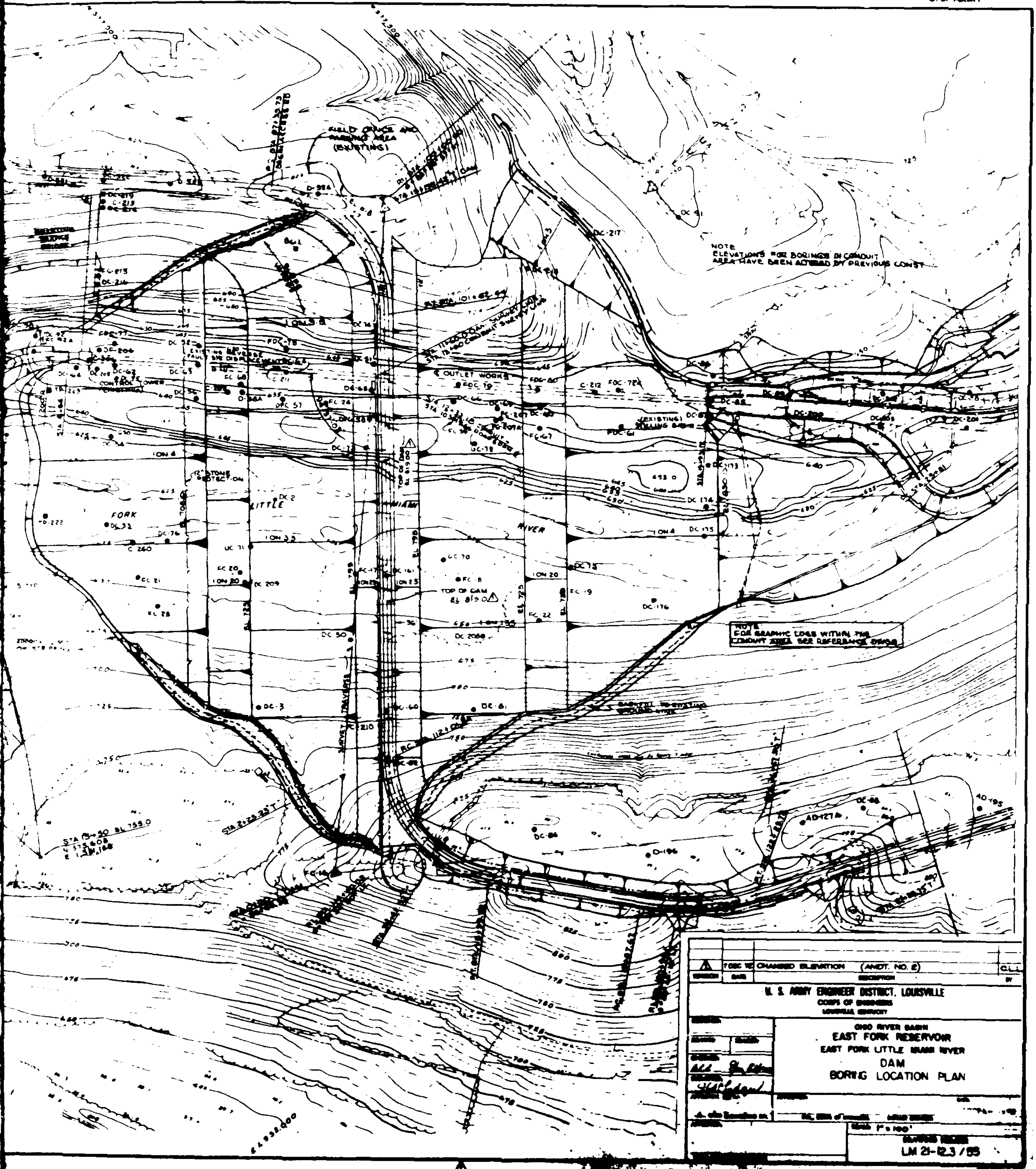



WASTE
Item 1
1,413,400
Item 3
245,000
144,200
118,100
67,200
1,843,700
83,400
52,500

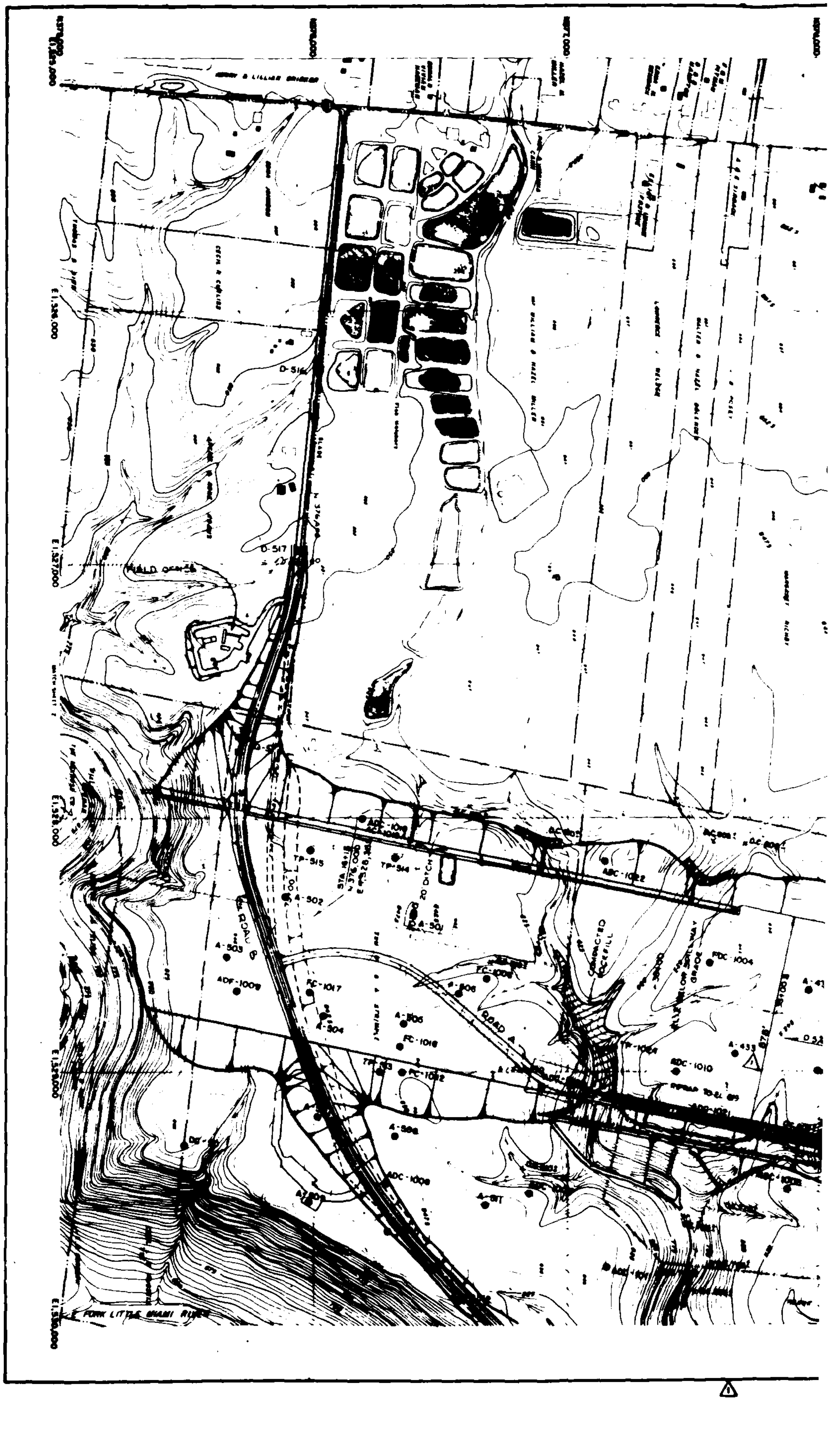
DM 5 PLATE 10*

CORPS OF ENGINEERS




FIELD OFFICE AND PARKING AREA (EXISTING)
NOTE
ELEVATIONS FOR BORINGS IN CONDUIT AREA HAVE BEEN ALTERED BY PREVIOUS CONST.
OUTLET WORKS
CONTROL TOWER (EXISTING)
(EXISTING) STILLING BASIN
12" STONE PROTECTION
FORK
LITTLE
MIAMI
RIVER
TOP OF DAM
NOTE
FOR GRAPHIC LOGS WITHIN THE CONDUIT AREA SEE REFERENCE DWGS.
CHANGED ELEVATION (AMDT. NO. 2)
C.L.L.
U. S. ARMY ENGINEER DISTRICT, LOUISVILLE
OHIO RIVER BASIN
EAST FORK RESERVOIR
EAST FORK LITTLE MIAMI RIVER
DAM
BORING LOCATION PLAN
1" = 100'
LM 21-123/55

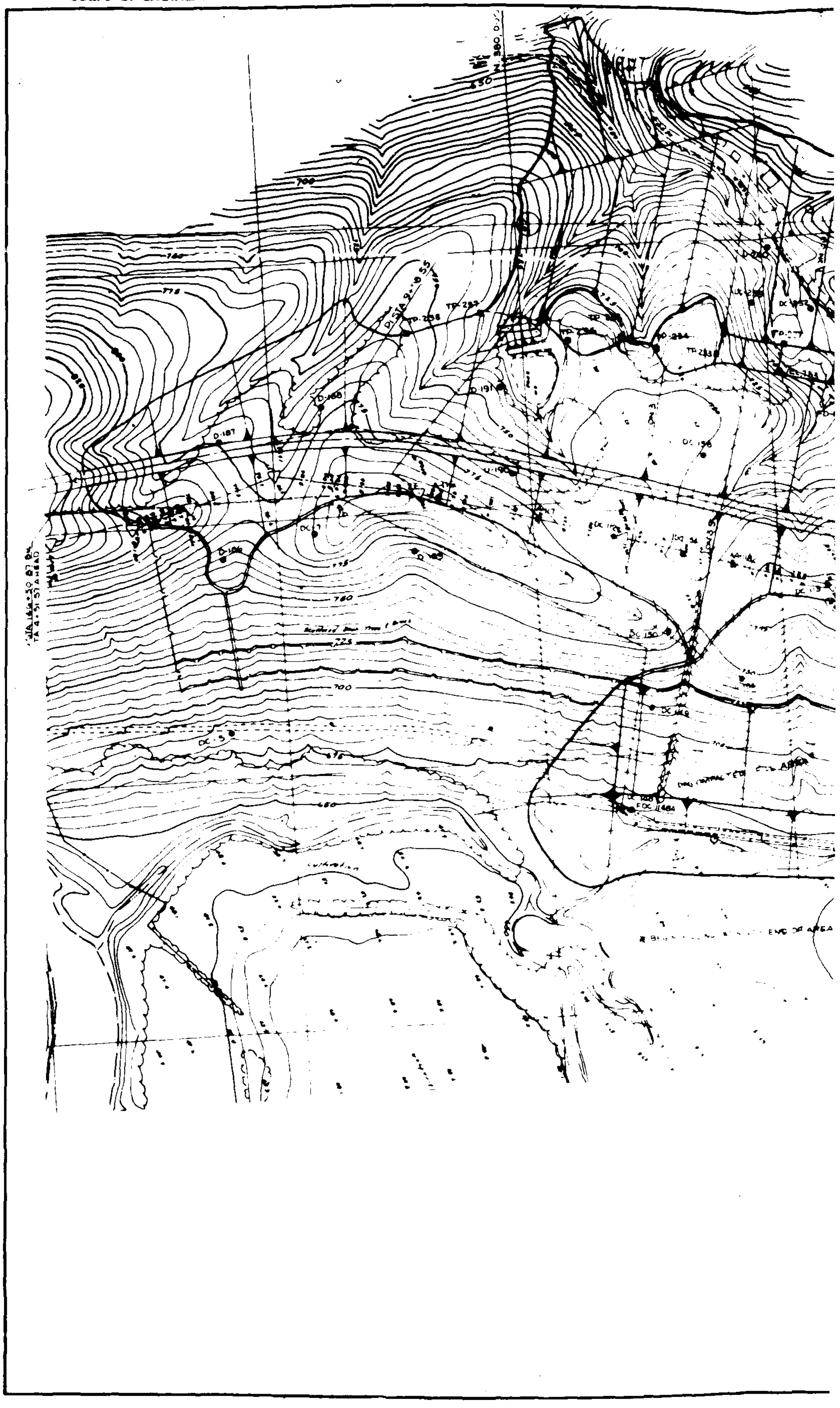
CORPS OF ENGINEERS



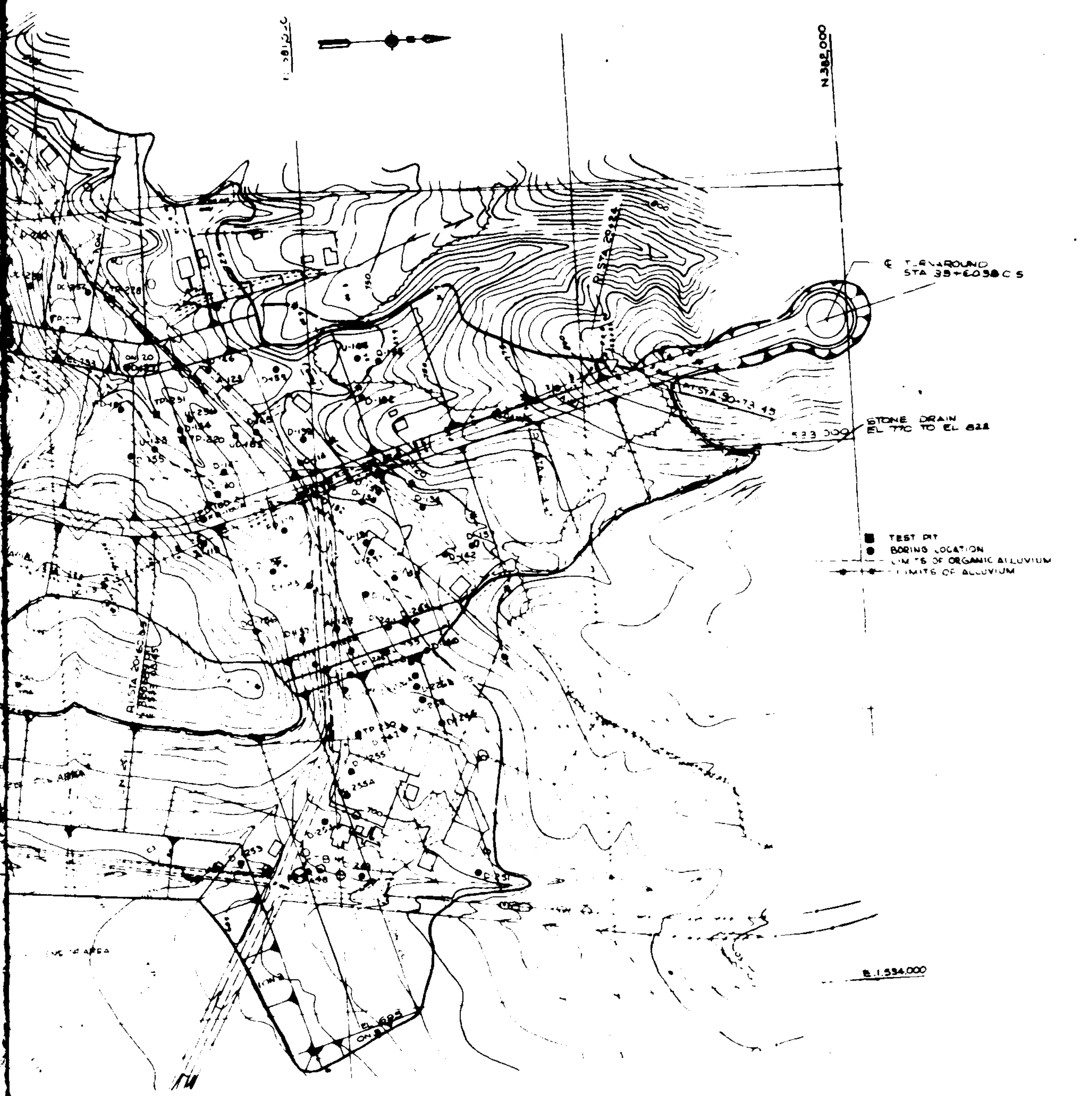
U. S. ARMY
LEGEND
OC: ELEVATIONS OF TOP OF ROCK OUTCROPS
SPILLWAY REVISED (AMDT. NO. 2)
U. S. ARMY ENGINEER DISTRICT, LOUISVILLE
CORPS OF ENGINEERS
OHIO RIVER BASIN
EAST FORK LAKE
EAST FORK LITTLE MIAMI RIVER
SPILLWAY
OCTOBER 1972
DRAWING NUMBER

PLATE 42

CORPS OF ENGINEERS



U. S. ARMY



U. S. ARMY ENGINEER DISTRICT, LOUISVILLE
CORPS OF ENGINEERS
LOUISVILLE, KENTUCKY

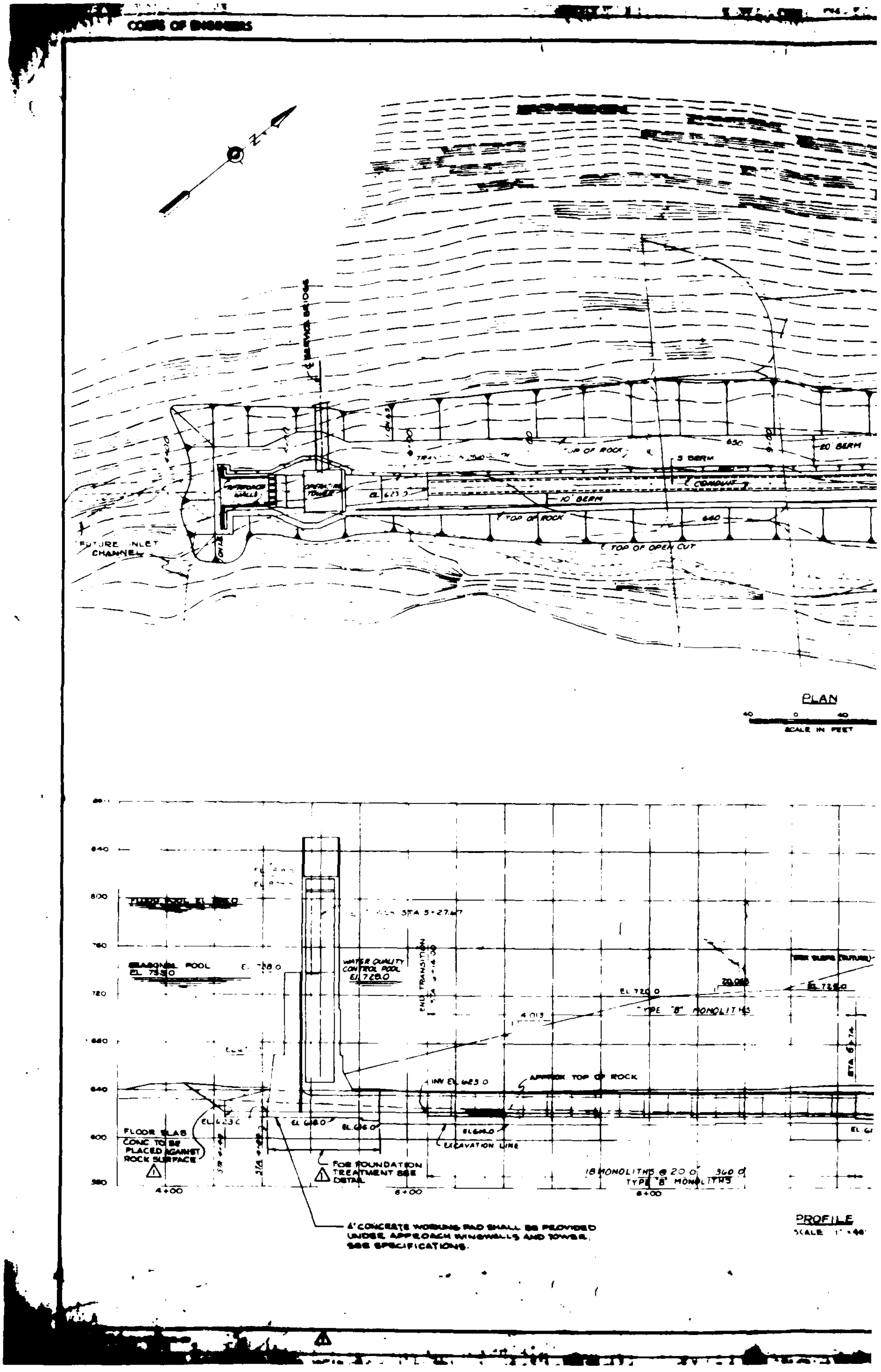
OHIO RIVER BASIN
EAST FORK RESERVOIR
EAST FORK LITTLE MIAMI RIVER
SADDLE DAM
BORING LOCATION PLAN

TRACED JRM

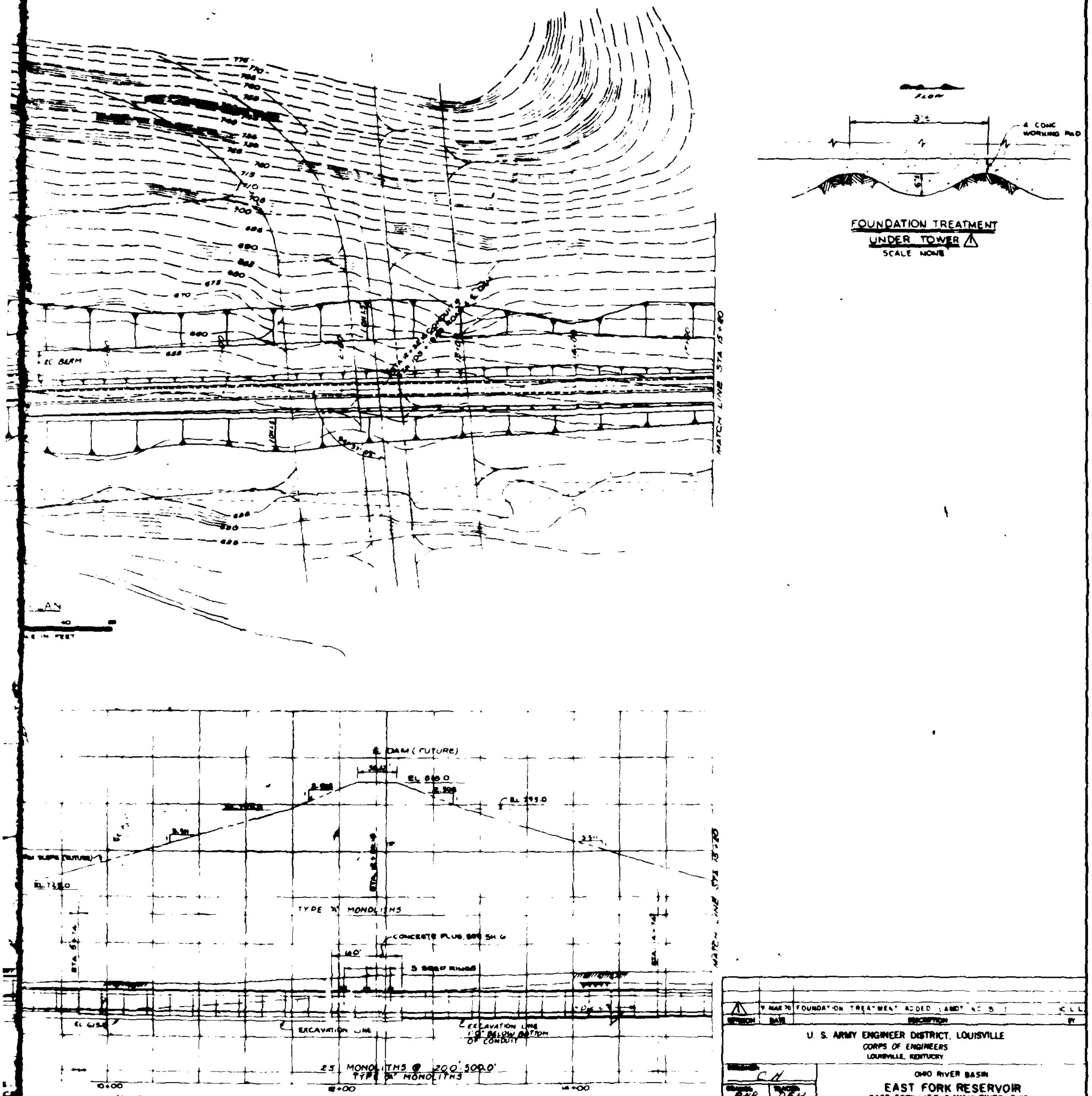
DATE OCTOBER 1972

DRAWING NUMBER
LM 21-12.3/56

PLATE 43


CORPS OF ENGINEERS
SERVICE BRIDGE
TOP OF ROCK
5' BERM
20' BERM
CONDUIT
10' BERM
TOP OF OPEN CUT
FUTURE INLET CHANNEL
PLAN
SCALE IN FEET
WATER QUALITY CONTROL POOL EL 728.0
TYPE "B" MONOLITHS
APPROX TOP OF ROCK
INV EL 623.0
EXCAVATION LINE
FLOOR SLAB
CONC TO BE PLACED AGAINST ROCK SURFACE
FOR FOUNDATION TREATMENT SEE DETAIL
18 MONOLITHS @ 20.0' 360.0'
TYPE "B" MONOLITHS
4' CONCRETE WORKING PAD SHALL BE PROVIDED UNDER APPROACH WINGWALLS AND TOWER. SEE SPECIFICATIONS.
PROFILE

U.S. ARMY



NOTE:
CONCRETE PLUG SHALL BE PLACED ON UPHILL SIDE OF CONDUIT OVER REACH SHOWN ON PROFILE.

△	9 MAR 70	FOUNDATION TREATMENT ADDED (AMDT NO. 5)	C.L.L.
REVISION	DATE	DESCRIPTION	BY

U. S. ARMY ENGINEER DISTRICT, LOUISVILLE
CORPS OF ENGINEERS
LOUISVILLE, KENTUCKY

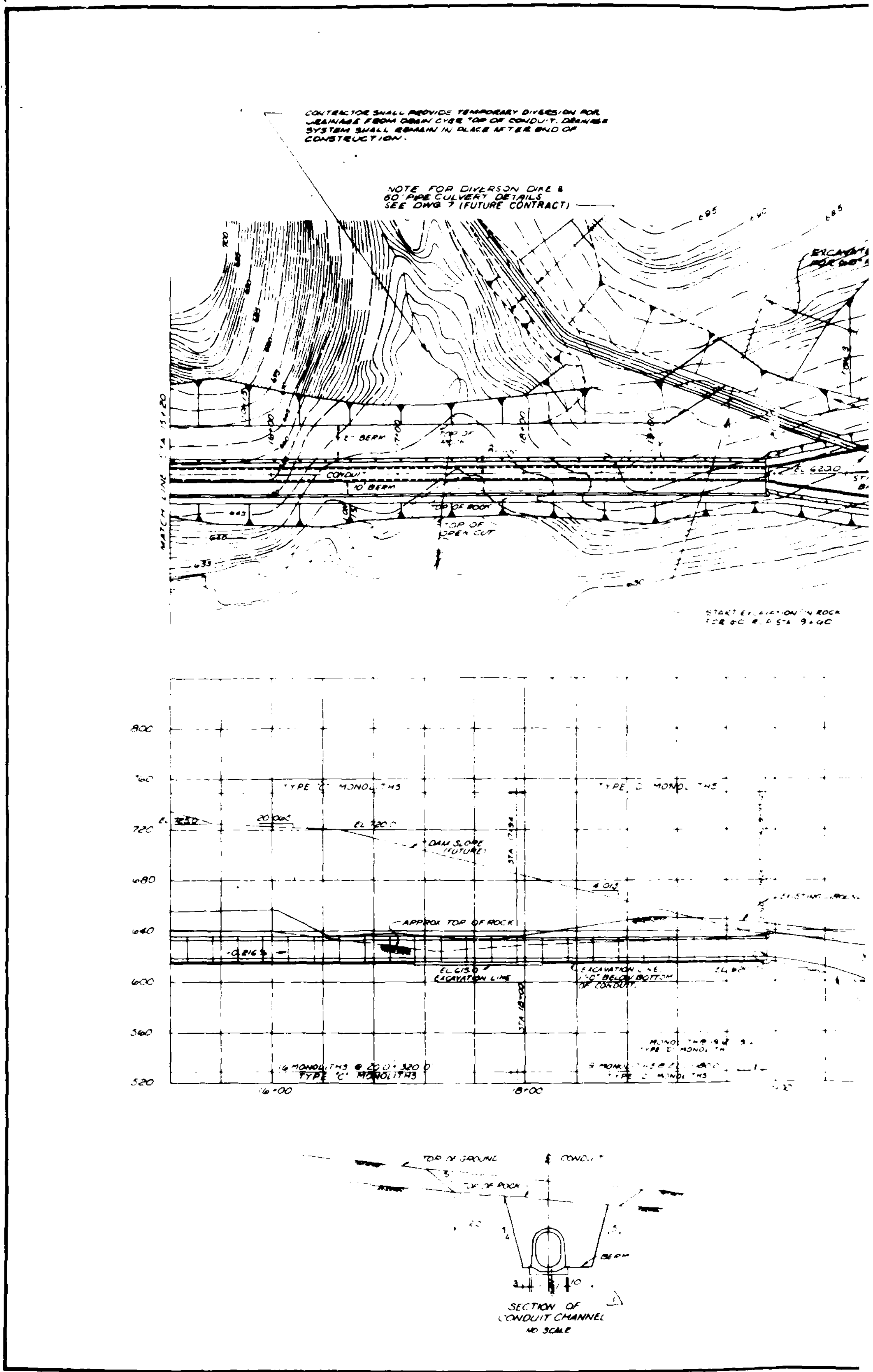
OHIO RIVER BASIN
EAST FORK RESERVOIR
EAST FORK LITTLE MIAMI RIVER, OHIO
OUTLET WORKS
PLAN & PROFILE
SHEET 1

BURGESS & NIPLE, LIMITED
COLUMBUS, OHIO

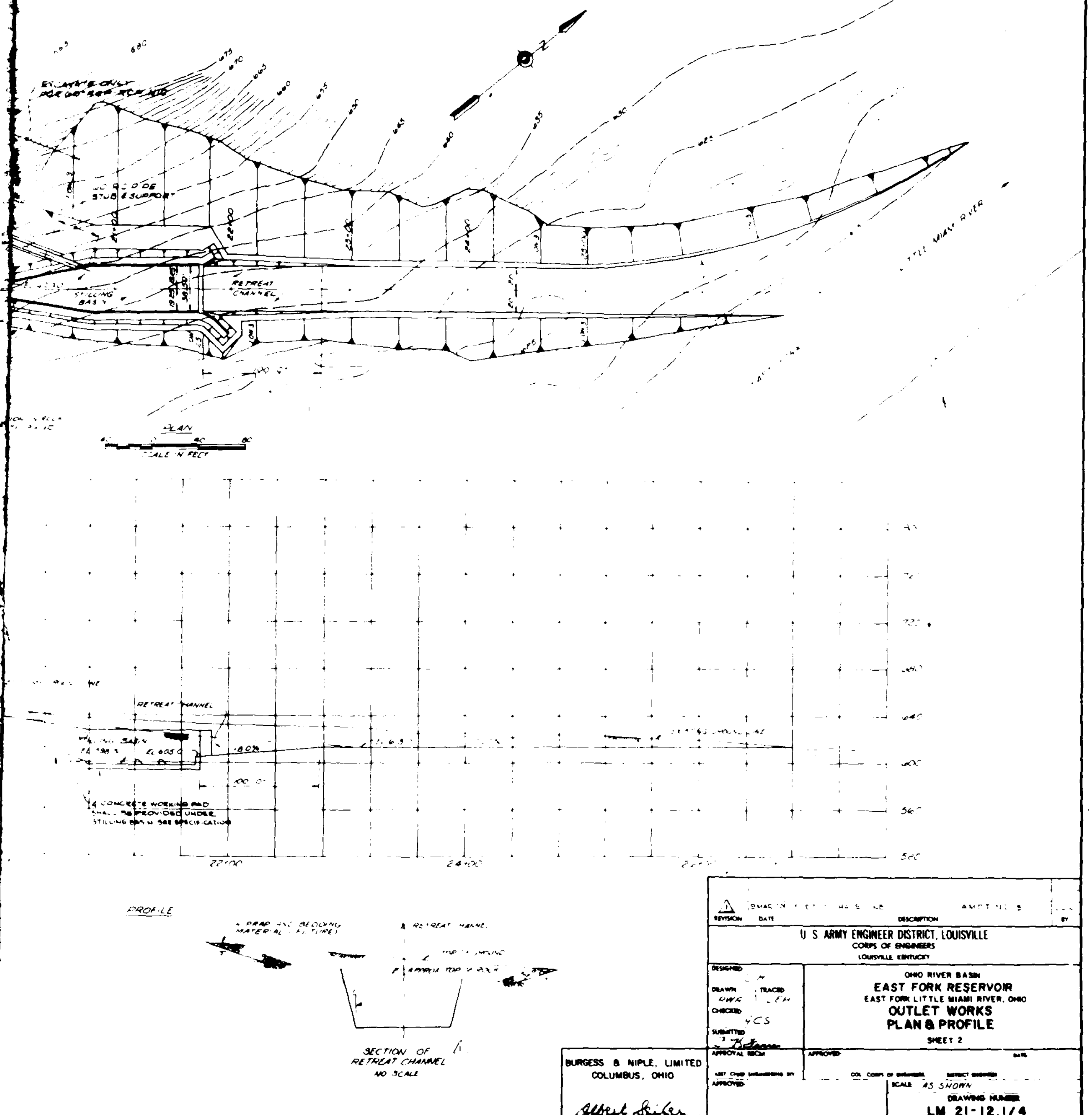
SCALE AS SHOWN
DRAWING NUMBER
LM 21-12.1/3

EXHIBIT

CORPS OF ENGINEERS



U S ARMY



U S ARMY ENGINEER DISTRICT, LOUISVILLE
CORPS OF ENGINEERS
LOUISVILLE, KENTUCKY

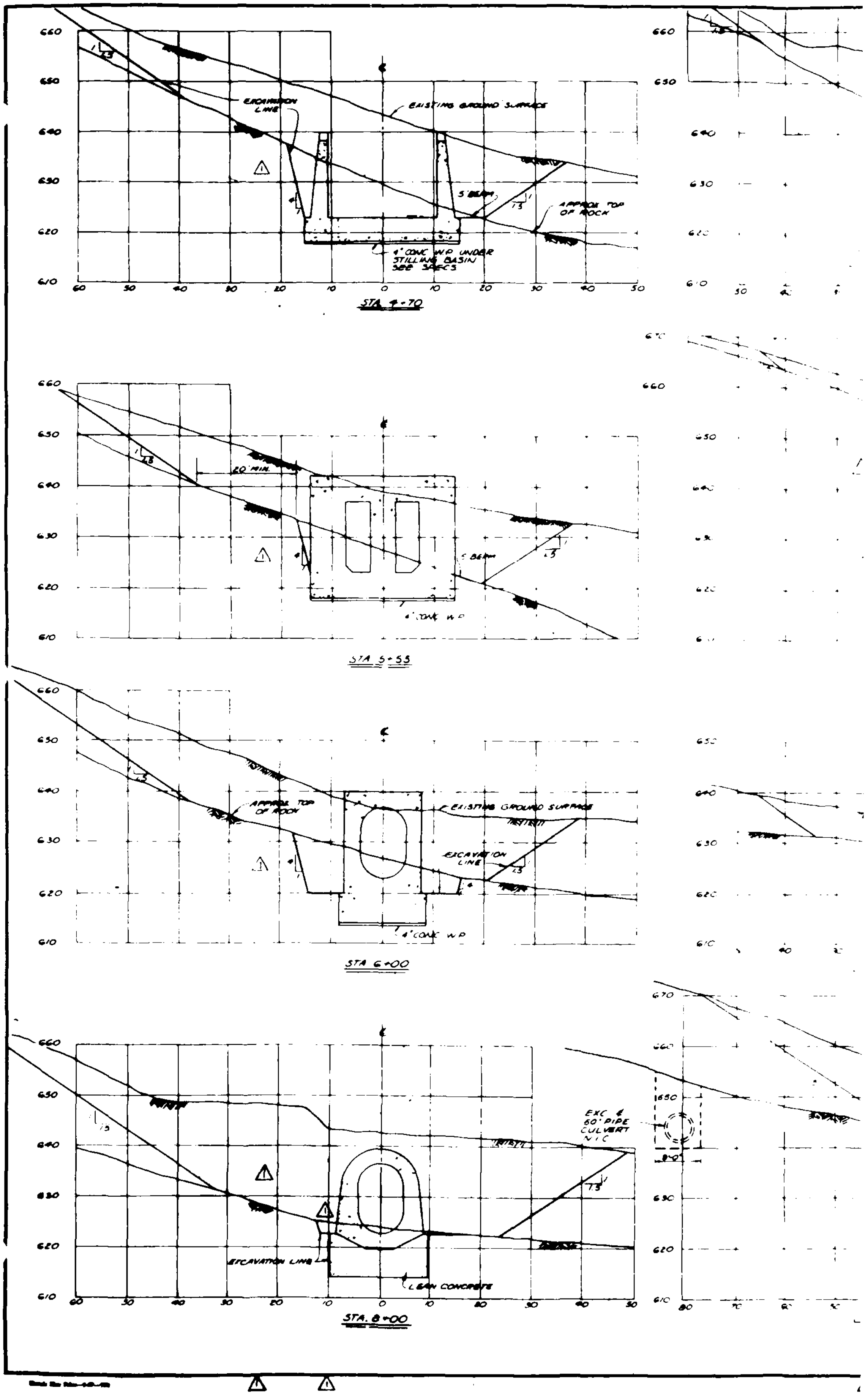
OHIO RIVER BASIN
EAST FORK RESERVOIR
EAST FORK LITTLE MIAMI RIVER, OHIO
OUTLET WORKS
PLAN & PROFILE
SHEET 2

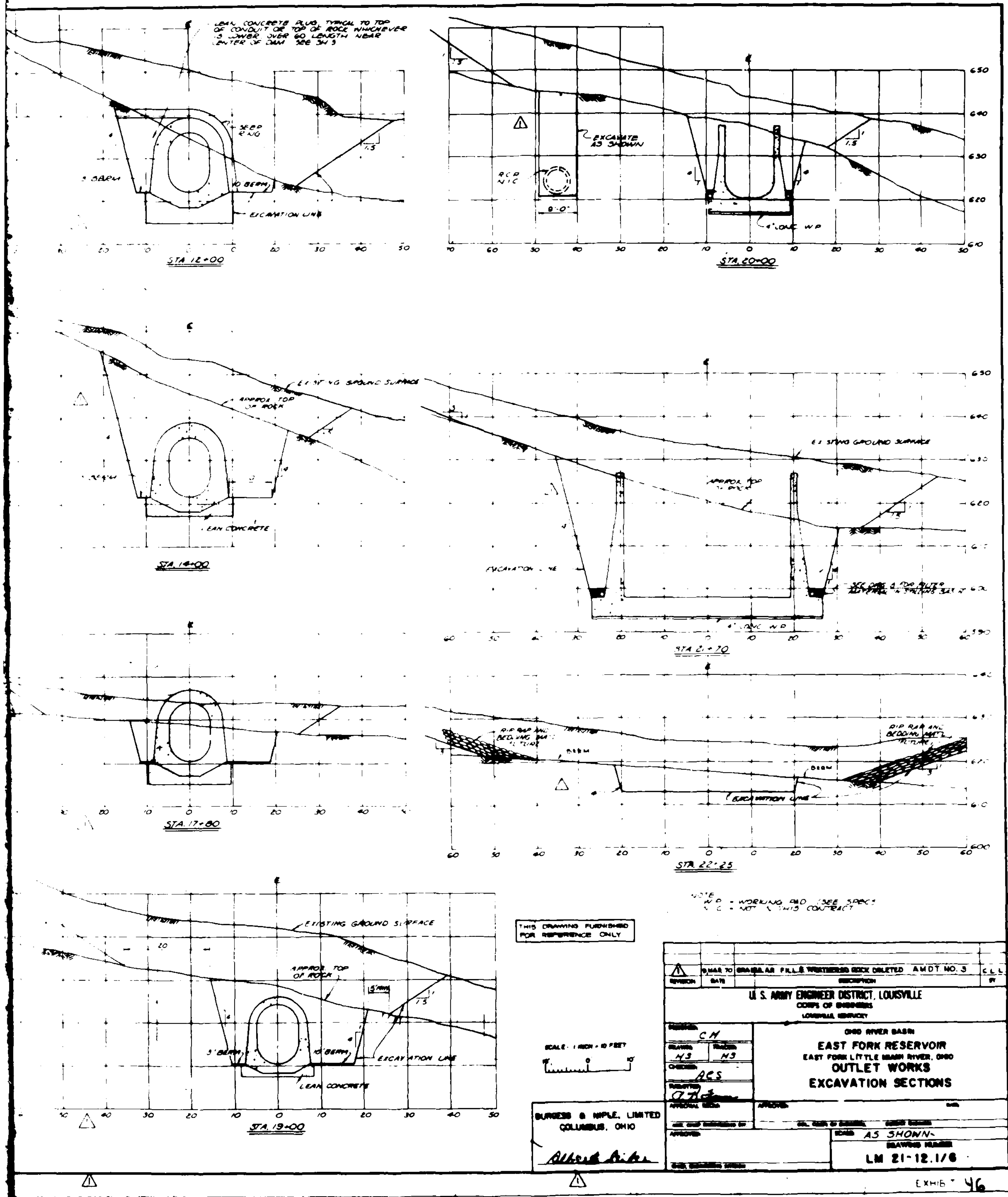
DESIGNED	
DRAWN RWG	TRACED LEH
CHECKED YCS	
SUBMITTED	
APPROVAL RECM	APPROVED
APPROVED	SCALE AS SHOWN
	DRAWING NUMBER LM 21-12.1/4

BURGESS & NIPLE, LIMITED
COLUMBUS, OHIO
Albert Seiler

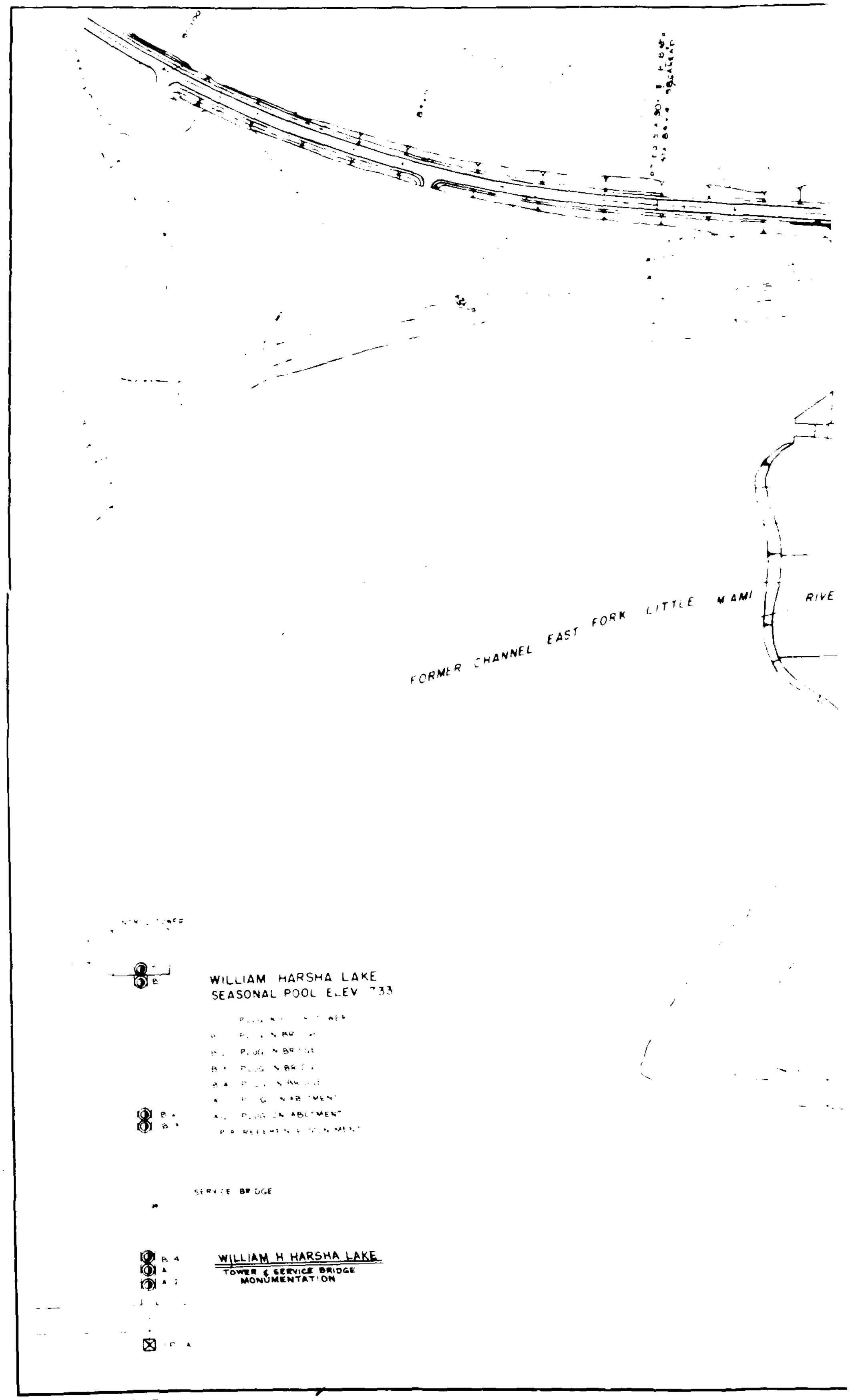
EXHIBIT 95

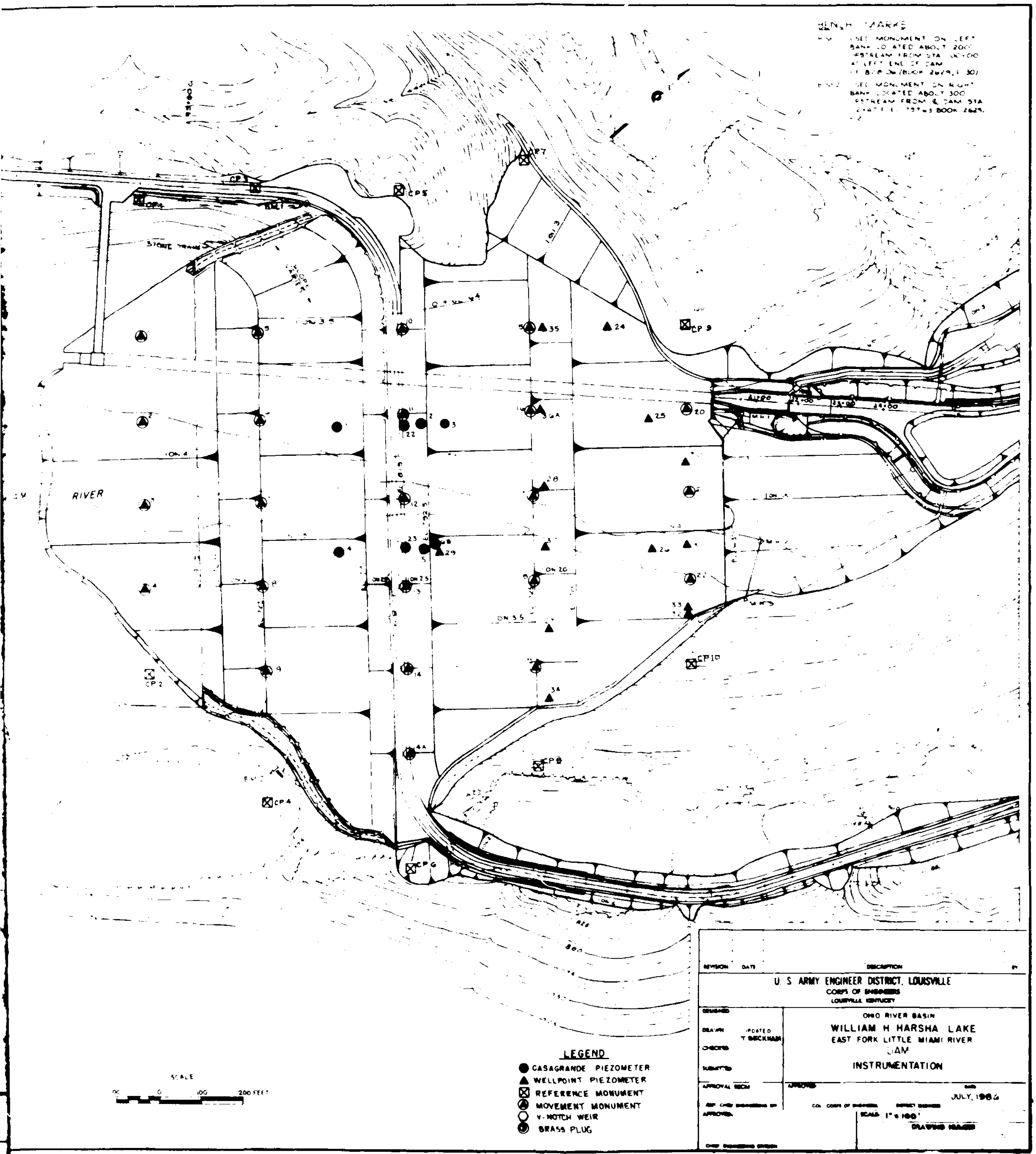
CORPS OF ENGINEERS




LEAN CONCRETE PLUG, TYPICAL TO TOP OF CONDUIT OR TOP OF ROCK WHICHEVER IS LOWER OVER 60 LENGTH NEAR CENTER OF DAM. SEE SH 3
EXCAVATION LINE
STA. 12+00
EXCAVATE AS SHOWN
RCP N.I.C.
8'-0"
4' LONG W.P.
STA. 20+00
EXISTING GROUND SURFACE
APPROX. TOP OF ROCK
LEAN CONCRETE
STA. 14+00
EXCAVATION LINE
STA. 21+70
STA. 17+80
RIP RAP AND BEDDING MAT'L. (FUTURE)
BERM
EXCAVATION LINE
STA. 22+25
NOTE
W.P. = WORKING PAD (SEE SPECS)
N.I.C. = NOT IN THIS CONTRACT
3' BERM
10' BERM
LEAN CONCRETE
STA. 19+00
THIS DRAWING FURNISHED FOR REFERENCE ONLY
SCALE: 1 INCH = 10 FEET
GRANULAR FILL & WEATHERED ROCK DELETED AMDT. NO. 3
U. S. ARMY ENGINEER DISTRICT, LOUISVILLE
CORPS OF ENGINEERS
LOUISVILLE, KENTUCKY
OHIO RIVER BASIN
EAST FORK RESERVOIR
EAST FORK LITTLE MIAMI RIVER, OHIO
OUTLET WORKS
EXCAVATION SECTIONS
BURGESS & NIPLE, LIMITED
COLUMBUS, OHIO
AS SHOWN
LM 21-12.1/6
EXHIBIT 46

CORPS OF ENGINEERS




RIVER
CP 1
CP 2
CP 3
CP 4
CP 5
CP 6
CP 7
CP 8
CP 9
CP10
LEGEND
CASAGRANDE PIEZOMETER
WELLPOINT PIEZOMETER
REFERENCE MONUMENT
MOVEMENT MONUMENT
V-NOTCH WEIR
BRASS PLUG
SCALE
100 0 100 200 FEET
U. S. ARMY ENGINEER DISTRICT, LOUISVILLE
CORPS OF ENGINEERS
LOUISVILLE, KENTUCKY
OHIO RIVER BASIN
WILLIAM H HARSHA LAKE
EAST FORK LITTLE MIAMI RIVER
DAM
INSTRUMENTATION
UPDATED T BECKHAM
JULY, 1986
SCALE 1" = 100'

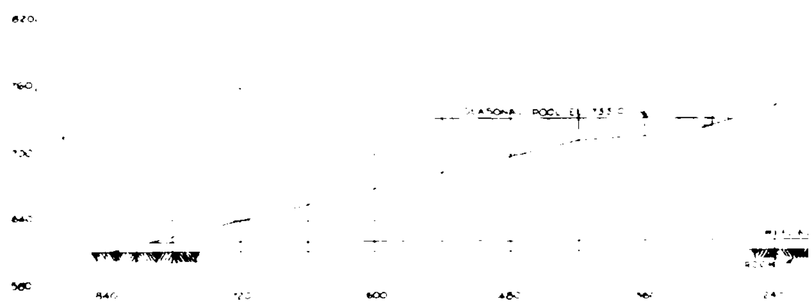
EMBANKMENT
PIEZOMETER INFORMATION

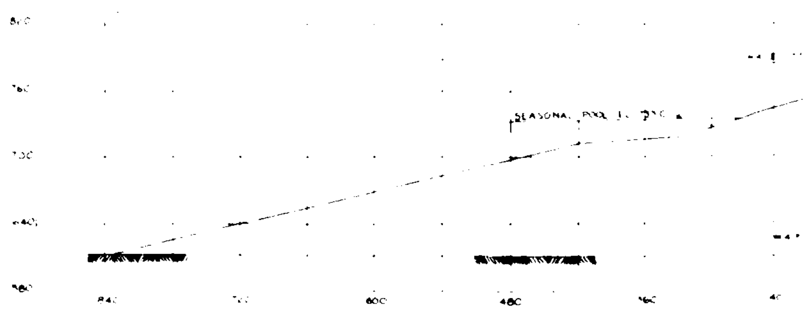
DAM STATION	NO.	LOCATION	ELEVATION	TYPE*
104+25	1	135' US	619.4	C
104+25	2	60' DS	700.0	C
104+30	22	20' DS	622.4	C
104+30	1	160' US	620.0	A
104+30	2	20' US	620.0	A
104+30	3	25' DS	745.0	A
107+15	4	165' US	633.0	A
107+20	4	140' US	621.4	C
107+20	5	60' DS	700.0	C
107+00	6B	100' DS	628.0	C
107+15	23	20' DS	621.8	C
107+15	5	35' US	623.6	A
107+15	6	25' DS	730.0	A
102+00	24	500' DS	633.2	C
104+25	25	600' DS	625.6	C
107+30	26	600' DS	606.1	C
109+10	27	350' DS	641.7	C
108+75	28	380' DS	611.4	C
108+65	33	680' DS	630.0	C
110+75	34	350' DS	703.8	C
102+00	35	360' DS	683.4	C
104+00	36	342' DS	610.7	C
107+20	37	350' DS	610.6	C

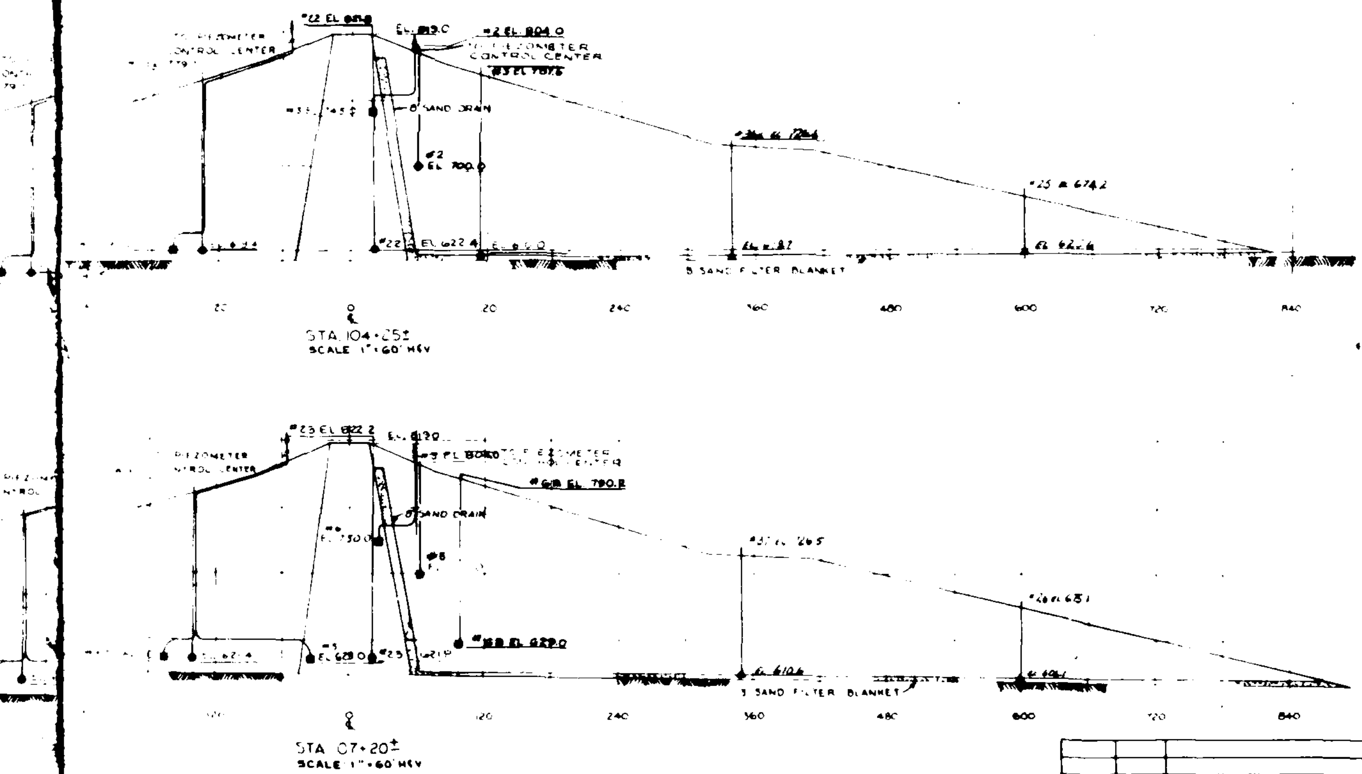
FOUNDATION
PIEZOMETER INFORMATION

DAM STATION	NO.	LOCATION	ELEVATION	TYPE*
104+25	3	115' DS	610.0	C
107+25	29	100' DS	668.9	C
105+25	30	680' DS	635.0	C
107+20	31	690' DS	630.9	C
108+76	32	690' DS	626.8	C

* A - PNEUMATIC
C - CASAGRANDE







LEGEND

- ● CASAGRANDE PIEZOMETER
- ■ PNEUMATIC PIEZOMETER
- ▲ WELLPOINT PIEZOMETER

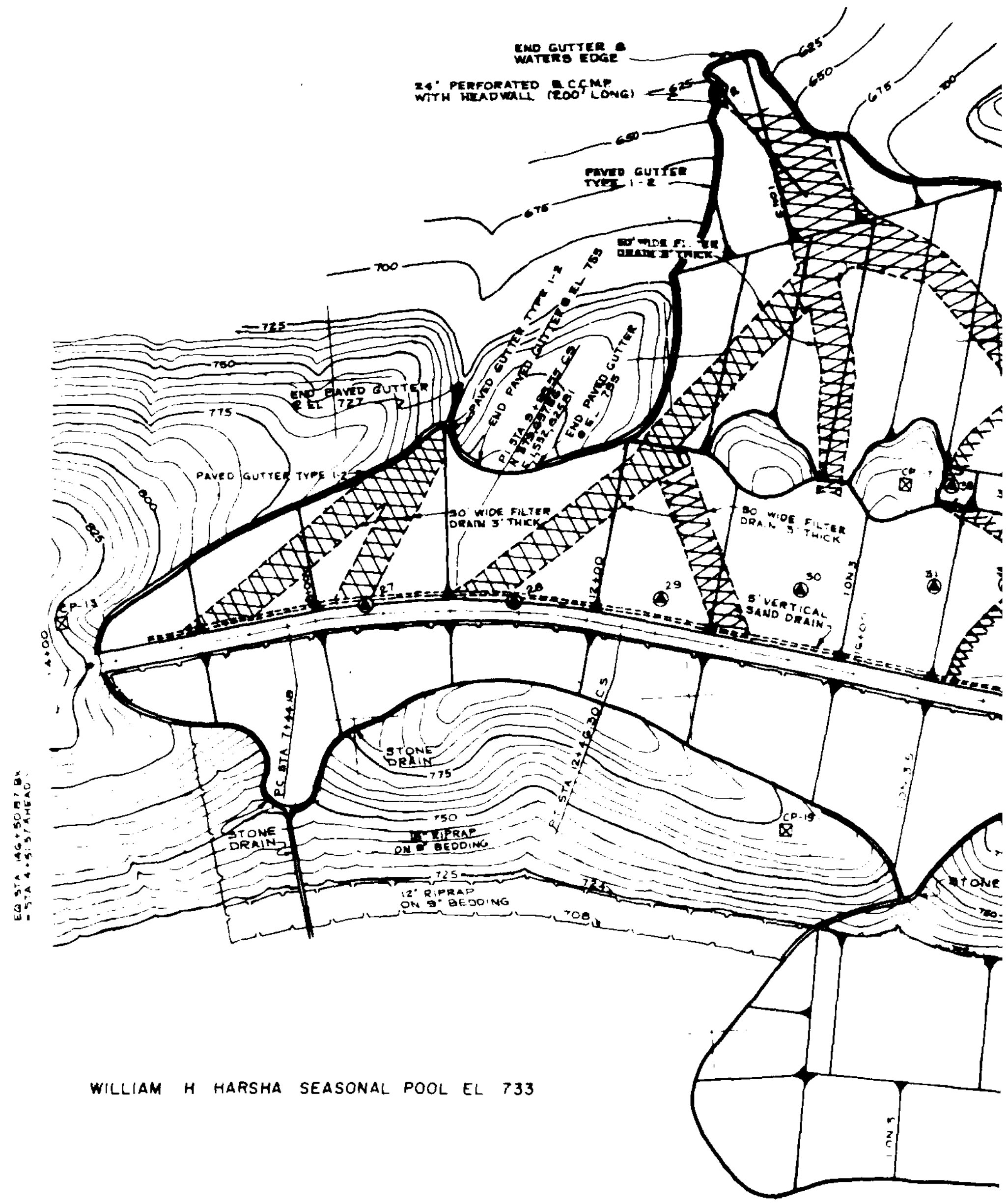
REVISION	DATE	DESCRIPTION	BY

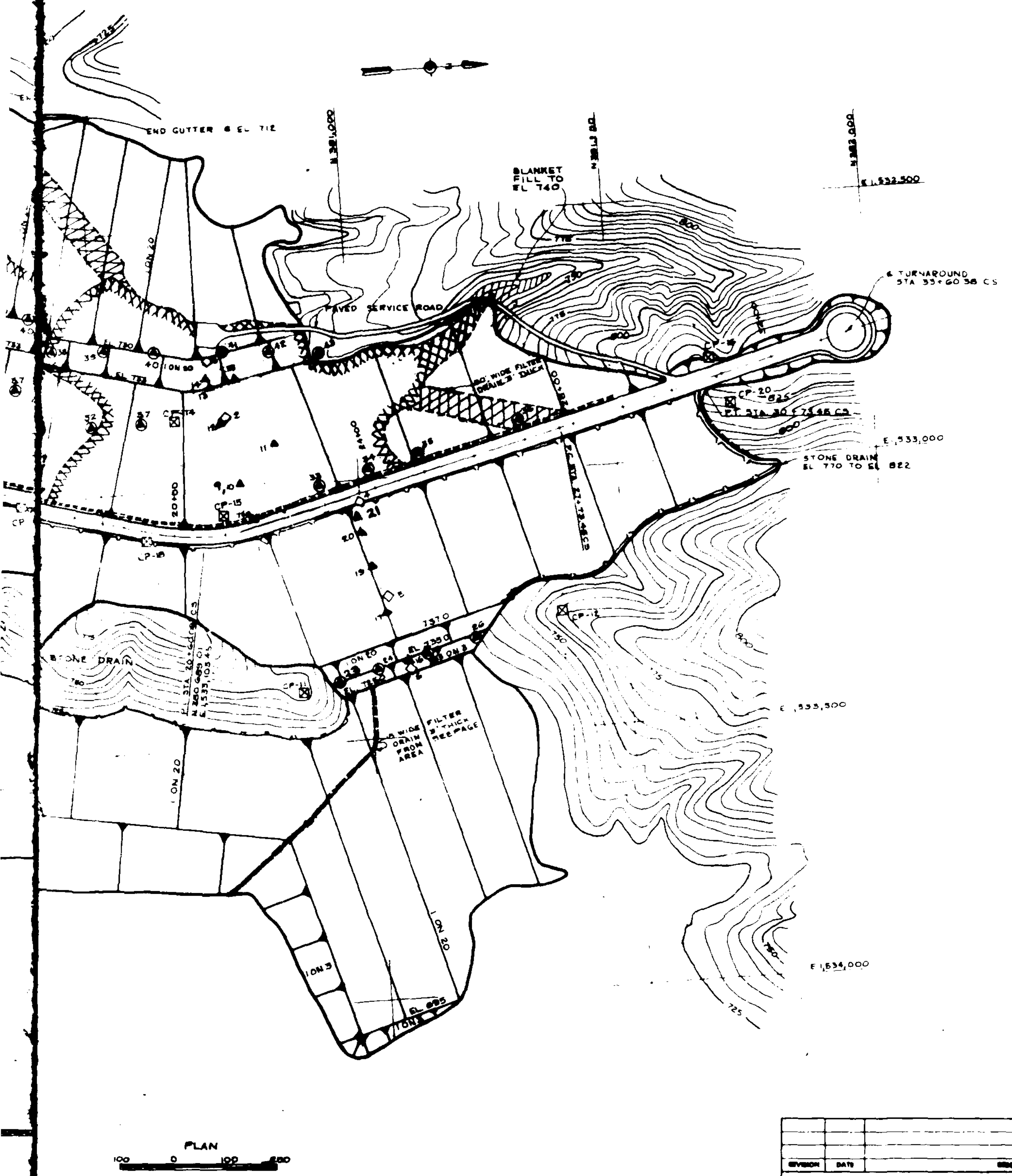
U. S. ARMY ENGINEER DISTRICT, LOUISVILLE
CORPS OF ENGINEERS
LOUISVILLE, KENTUCKY

DESIGNED
DRAWN — TRACED E.J.H.
CHECKED
SUBMITTED
SCALE

OHIO RIVER BASIN
WILLIAM H. HARSHA LAKE
EAST FORK LITTLE MIAMI RIVER
DAM
INSTRUMENTATION

DATE OCTOBER, 1981
DRAWING NUMBER


END GUTTER @ WATERS EDGE
24" PERFORATED C.C.M.P. WITH HEADWALL (200' LONG)
PAVED GUTTER TYPE 1-2
END PAVED GUTTER @ EL 727
PAVED GUTTER TYPE 1-2
30' WIDE FILTER DRAIN 3' THICK
5' VERTICAL SAND DRAIN
STONE DRAIN
12" RIPRAP ON 9" BEDDING
WILLIAM H HARSHA SEASONAL POOL EL 733



▲ CASAGRANDE PIEZOMETER

⊠ REFERENCE MONUMENT

● MOVEMENT MONUMENT

○ V-NOTCH WEIR

◇ SETTLEMENT PLATE

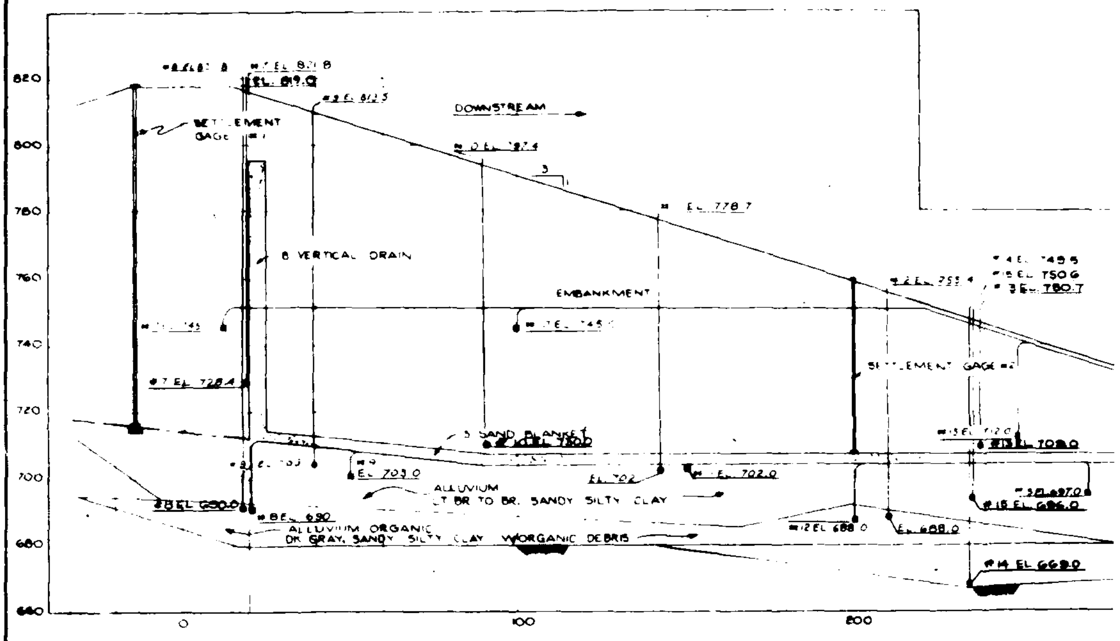
REVISION	DATE	DESCRIPTION	BY	APP'D

U. S. ARMY ENGINEER DISTRICT, LOUISVILLE
CORPS OF ENGINEERS
LOUISVILLE, KENTUCKY

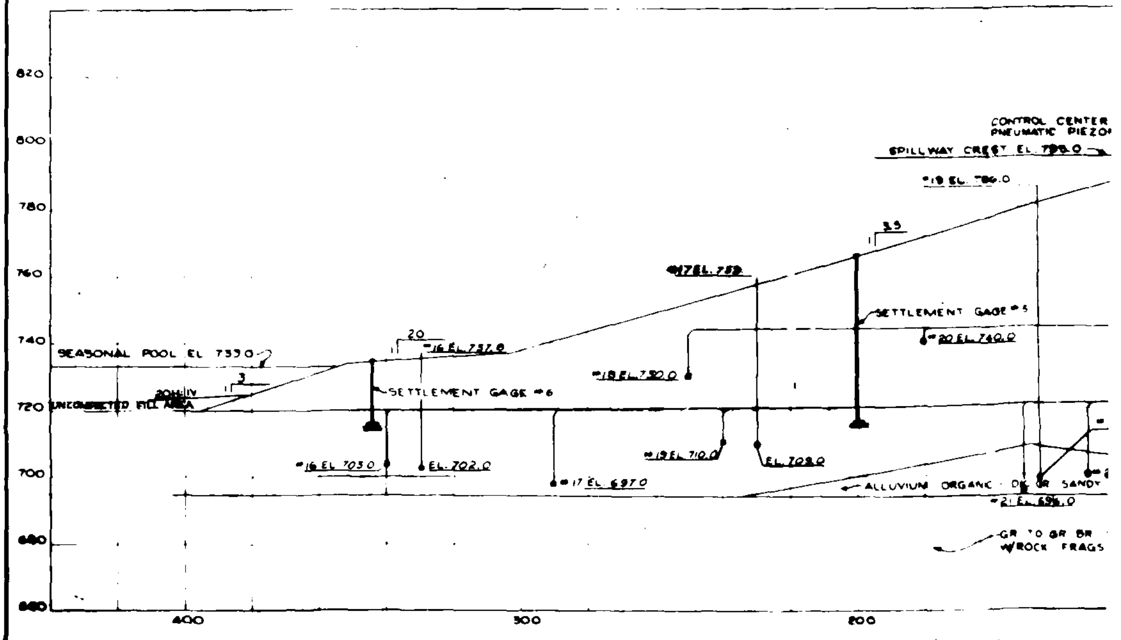
OHIO RIVER BASIN
WILLIAM H. HARSHA LAKE
EAST FORK LITTLE MIAMI RIVER
SADDLE DAM
INSTRUMENTATION

DESIGNED:
DRAWN:
TRACED:
CHECKED:
SUBMITTED:
SCALE: 1" = 100 FT
DATE: 13 AUGUST, 1981
DRAWING NUMBER

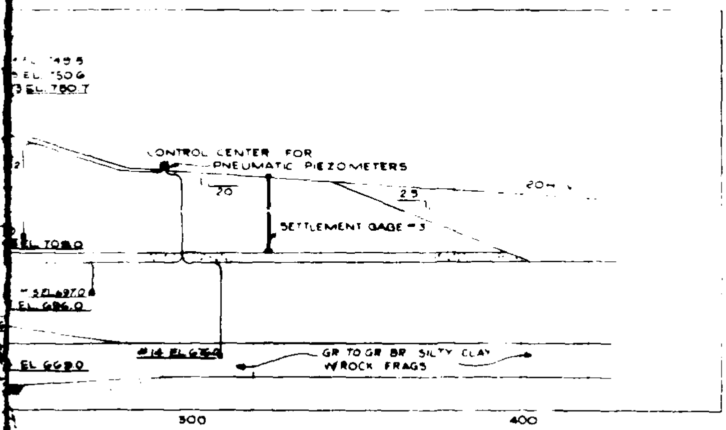
CORPS OF ENGINEERS



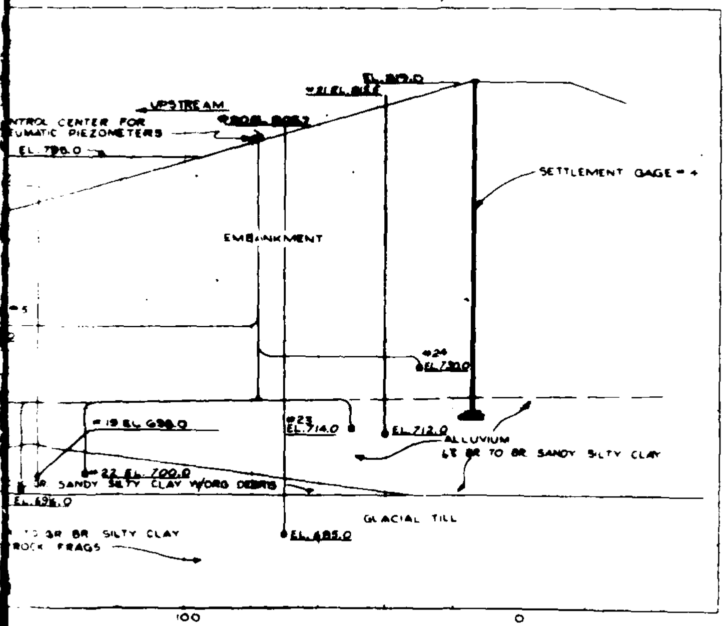
STA. 21+70/21+60/22+45/2
SCALE: 1"=20.0' H&V



STA. 23+60/23+50
SCALE: 1"=20.0' H&V



0/22+45/22+15/22+05



FOUNDATION PIEZOMETER INFORMATION

SADDLE DAM STATION	LOCATION	TIP ELEVATION	PIEZOMETER TYPE *	NUMBER
21+70	50' DS	703.0	A	9
21+60	20' DS	690.0	C	8
22+45	150' DS	702.0	A	11
22+45	140' DS	702.0	C	11
21+70	200' DS	688.0	A	12
21+60	210' DS	688.0	C	12
22+05	278' DS	687.0	A	15
22+15	235' DS	696.0	C	15
21+60	40' DS	703.0	C	9
21+70	20' DS	690.0	A	8
21+60	234' DS	669.0	C	14
21+70	310' DS	676.0	A	14
23+60	50' US	714.0	A	23
23+50	40' US	712.0	C	21
23+60	130' US	700.0	A	22
23+50	145' US	698.0	C	19
23+50	180' US	686.0	A	21
23+50	230' US	709.0	C	17
23+60	240' US	710.0	A	19
23+60	330' US	702.0	C	16
23+60	340' US	703.0	A	16
23+50	70' US	685.0	C	20
23+60	200' US	697.0	A	17

* A = PNEUMATIC
C = CASAGRANDE

EMBANKMENT PIEZOMETER INFORMATION

SADDLE DAM STATION	LOCATION	TIP ELEVATION	PIEZOMETER TYPE *	NUMBER
21+70	12' DS	745.0	A	7
21+70	100' DS	740.0	A	10
21+60	80' DS	730.0	C	10
21+70	230' DS	712.0	A	13
21+70	230' DS	703.0	C	13
23+60	30' US	750.0	A	24
23+60	180' US	740.0	A	20
23+60	230' US	730.0	A	18
21+60	20' DS	720.4	C	7

SETTLEMENT GAGE INFORMATION

SADDLE DAM STATION	LOCATION	INITIAL PLATE ELEVATION	NUMBER
21+70	200' DS	705.28	2
	325' DS	699.96	3
	15' US	718.17	1
23+60	15' US	717.76	4
	200' US	715.84	5
	344' US	715.05	6

LEGEND

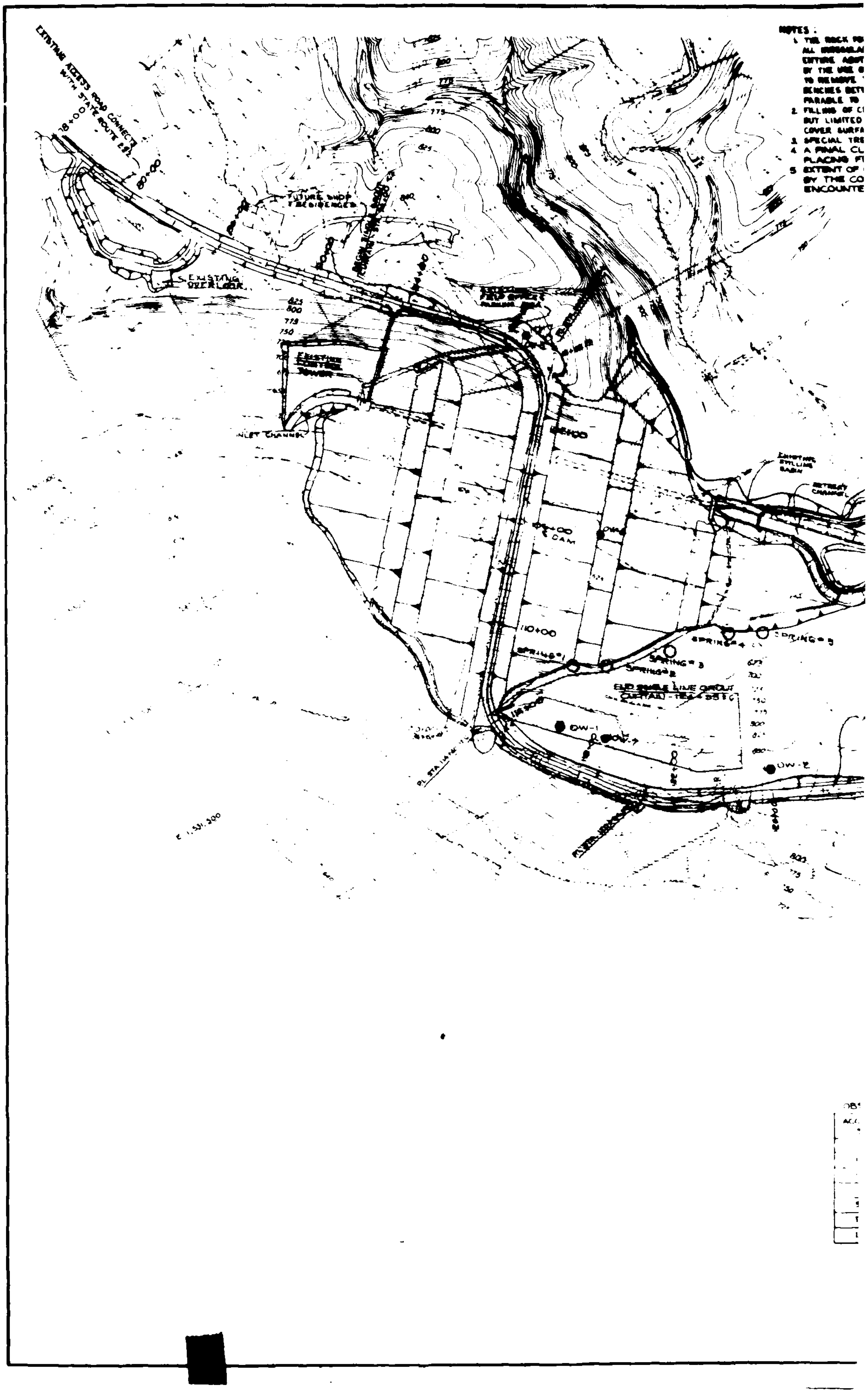
● CASAGRANDE PIEZOMETER
■ PNEUMATIC PIEZOMETER

REVISION	DATE	DESCRIPTION	BY

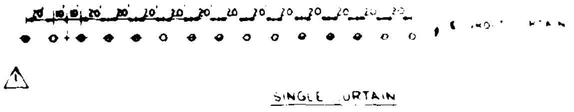
U. S. ARMY ENGINEER DISTRICT, LOUISVILLE
CORPS OF ENGINEERS
LOUISVILLE KENTUCKY

OHIO RIVER BASIN
WILLIAM H. HARSHA LAKE
EAST FORK LITTLE MIAMI RIVER
SADDLE DAM
INSTRUMENTATION

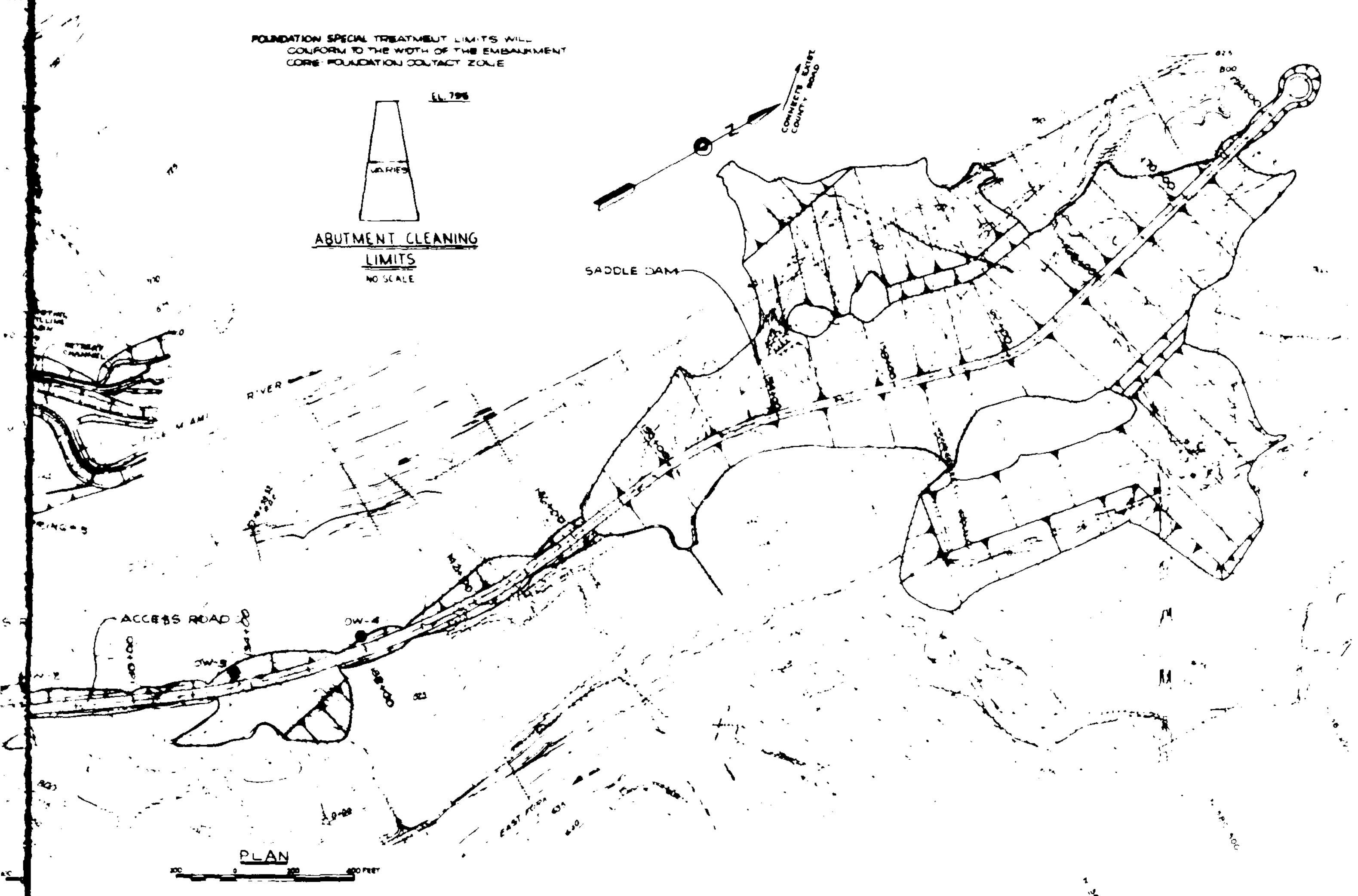
DESIGNED
DRAWN | TRACED E.J.H.
CHECKED
SUBMITTED
SCALE
DATE OCTOBER, 1981
DRAWING NUMBER


EXISTING OVERLOOK
FUTURE SHOP & RESIDENCES
EXISTING CONTROL TOWER
INLET CHANNEL
SPRING #1
SPRING #2
SPRING #3
SPRING #4
SPRING #5
OW-1
OW-2
110+00
NOTES:

NOTES:
1. THE ROCK FOUNDATION AND ABUTMENTS SHALL BE CLEANED WITHIN THE LIMITS OF THE SPECIAL TREATMENT AREA. ALL IRREGULARITIES SHALL BE REMOVED OR TRIMMED BACK TO FORM A REASONABLY UNIFORM SLOPE ON THE ENTIRE ABUTMENT. OVERHANGS WILL NOT BE PERMITTED AT ANY LOCATION AND SHALL BE REMEDIED EITHER BY THE USE OF CONCRETE "DENTAL TREATMENT" TO FILL THE DEPRESSIONS, OR BY DRILLING AND BLASTING TO REMOVE THE OVERHANGING ROCK. VERTICAL SURFACES SHALL NOT BE HIGHER THAN 5 FEET AND THE BENCHES BETWEEN VERTICAL SURFACES SHALL BE OF SUCH WIDTH AS TO PROVIDE A STEPPED SLOPE COMPARABLE TO THE UNIFORM SLOPE ON ADJACENT AREAS.
2. FILLING OF CRACKS OR FISSURES WITHIN THE SPECIAL TREATMENT AREA SHALL BE WITH LEAN CONCRETE BUT LIMITED TO THE OPENINGS IN THE ROCK SURFACE, AND THIN LAYERS OF LEAN CONCRETE SHALL NOT COVER SURFACE AREAS OF SOUND ROCK WHERE IT MIGHT CRACK OFF UNDER ROLLING ACTION.
3. SPECIAL TREATMENT AREA SHALL EXTEND BETWEEN ELEVATION 795 (SPILLWAY CREST) AT EACH ABUTMENT.
4. A FINAL CLEANUP IN THE SPECIAL TREATMENT AREA SHALL BE MADE JUST PRIOR TO PLACING FILL.
5. EXTENT OF CUT-OFF TRENCH AND GROUT CURTAIN ARE APPROXIMATE AND MAY BE EXTENDED BY THE CONTRACTING OFFICER TO REMOVE PERVIOUS MATERIAL WHICH MAY BE ENCOUNTERED FURTHER IN THE ABUTMENTS.



GROUT CURTAIN SPACING



PLAN

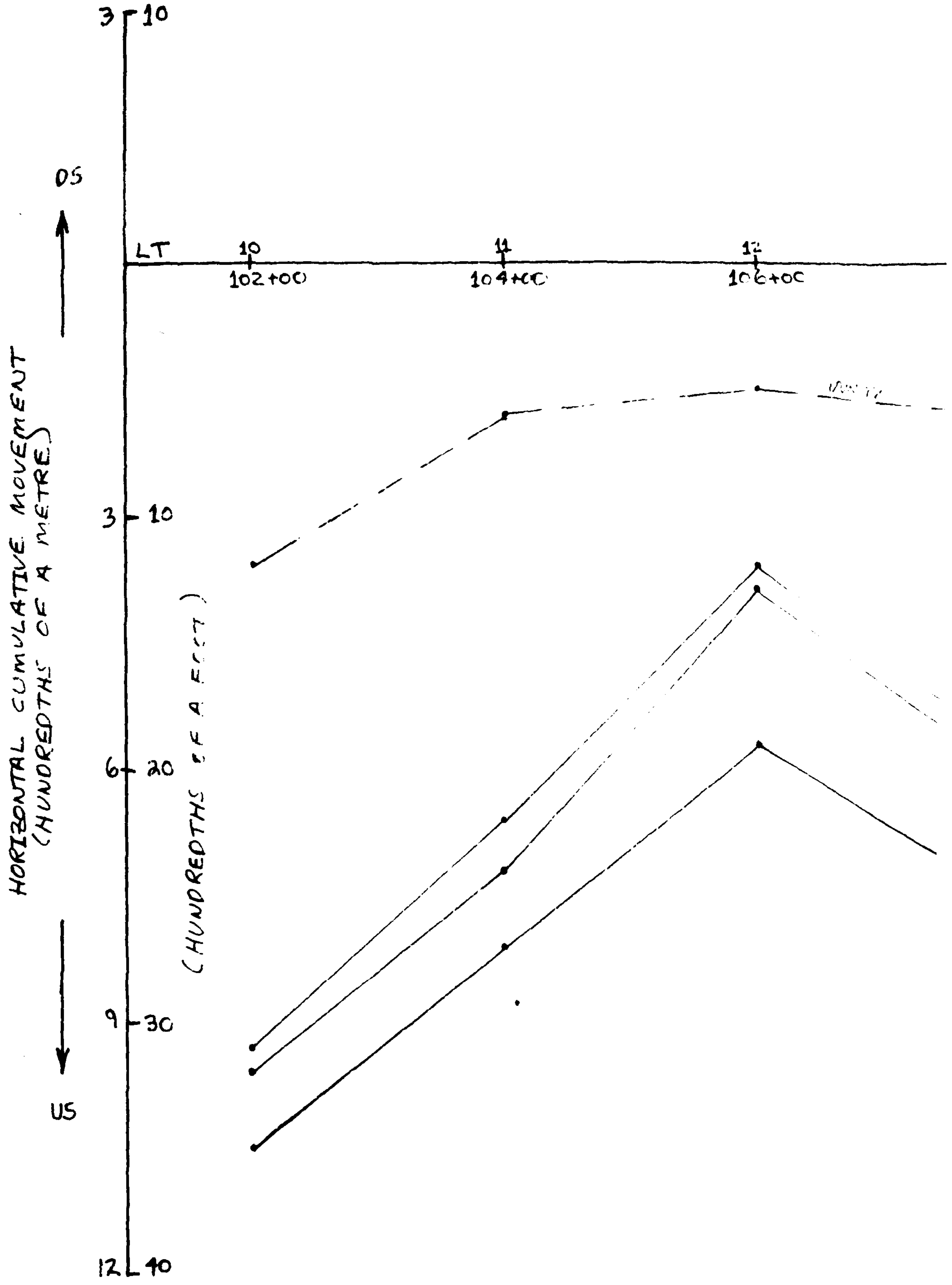
OBSERVATION WELL INFORMATION

ACCESS ROAD STATION	OFFSET	TIP ELEV.	TYPE MAT'L	TYPE	NUMBER
6 + 60	50' DS	619.8	BEDROCK	WELLPOINT	OW-1
126 + 00	00 DS	618.5	BEDROCK	WELLPOINT	OW-2
133 + 50	50 DS	622.9	BEDROCK	WELLPOINT	OW-3
138 + 00	50' DS	623.1	BEDROCK	WELLPOINT	OW-4
99 + 00	80' US	618.4	BEDROCK	WELLPOINT	OW-5
105 + 75	317' DS	628.8	FILL (SM)	WELLPOINT	OW-6
118 + 50	800' DS	618.3	BEDROCK	WELLPOINT	OW-7

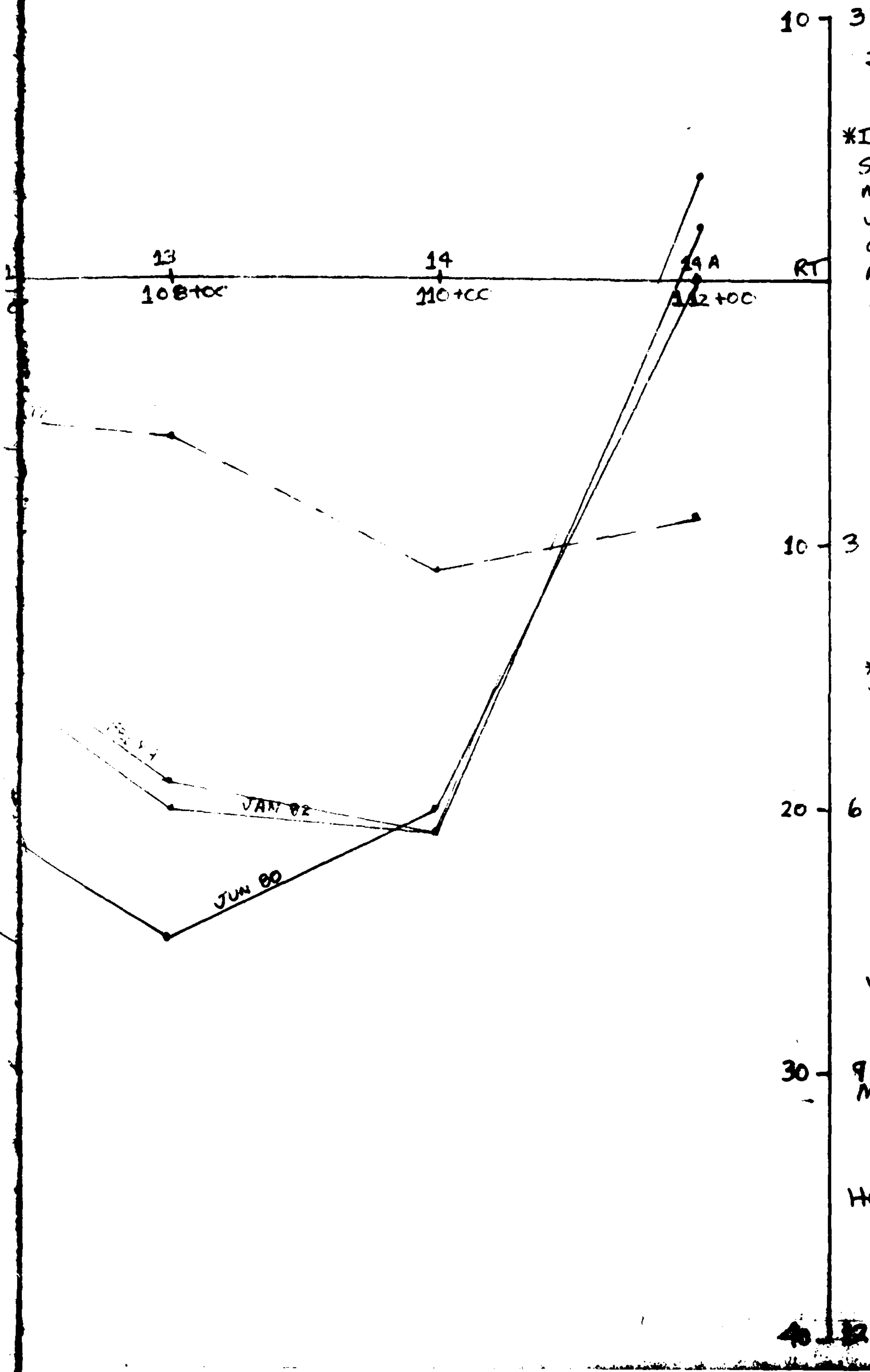
U. S. ARMY ENGINEER DISTRICT, LOUISVILLE
CORPS OF ENGINEERS
LOUISVILLE, KENTUCKY

OHIO RIVER BASIN
WILLIAM H. HARSHA LAKE
EAST FORK LITTLE MIAMI RIVER
PLAN OF OBSERVATION WELLS

OCTOBER, 1981
SCALE 1" = 200'



HORIZONTAL CUMULATIVE MOVEMENT
(HUNDREDTHS OF A METRE)
(HUNDREDTHS OF A FOOT)
DS
US
LT
10
11
12
102+00
104+00
106+00
3
10
6
20
9
30
12
40



INITIAL READINGS
JUN77 ---

*INTERMEDIATE READINGS
SEP77, DEC77, FEB78
MAR78, APR78, MAY78
JUN78, JUL78, AUG78
OCT78, FEB79, MAR79
APR79, OCT79, MAR80
AUG80, JAN81, APR81
JUN82, JAN83, MAY83
FEB85, SEP86

* INTERMEDIATE READINGS
WERE NOT PLOTTED
BECAUSE NO
SIGNIFICANT CHANGE
WAS NOTED FROM
PREVIOUS READINGS

WILLIAM H. HARSHA

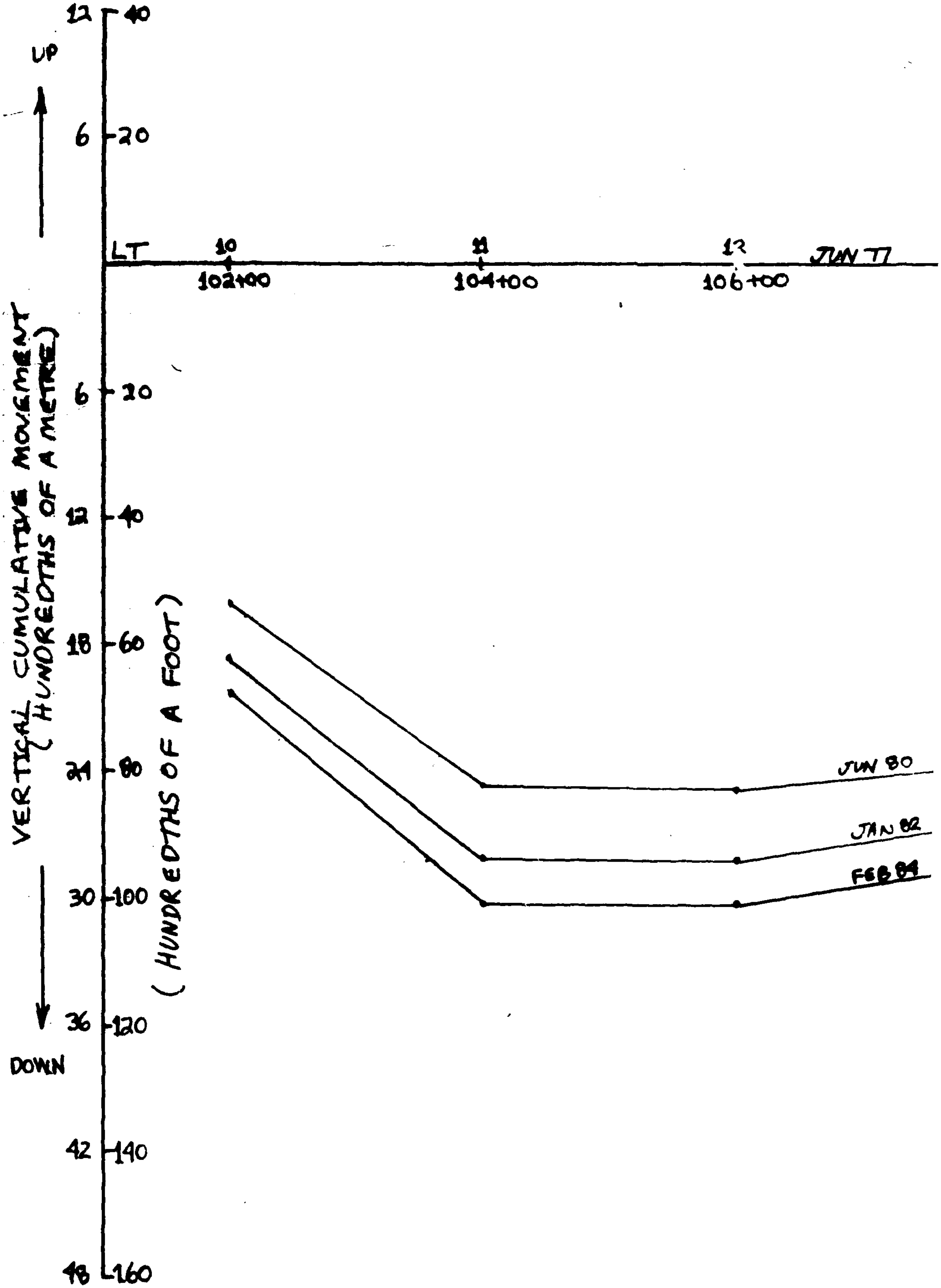
MAIN DAM

MOVEMENT MONUMENTS

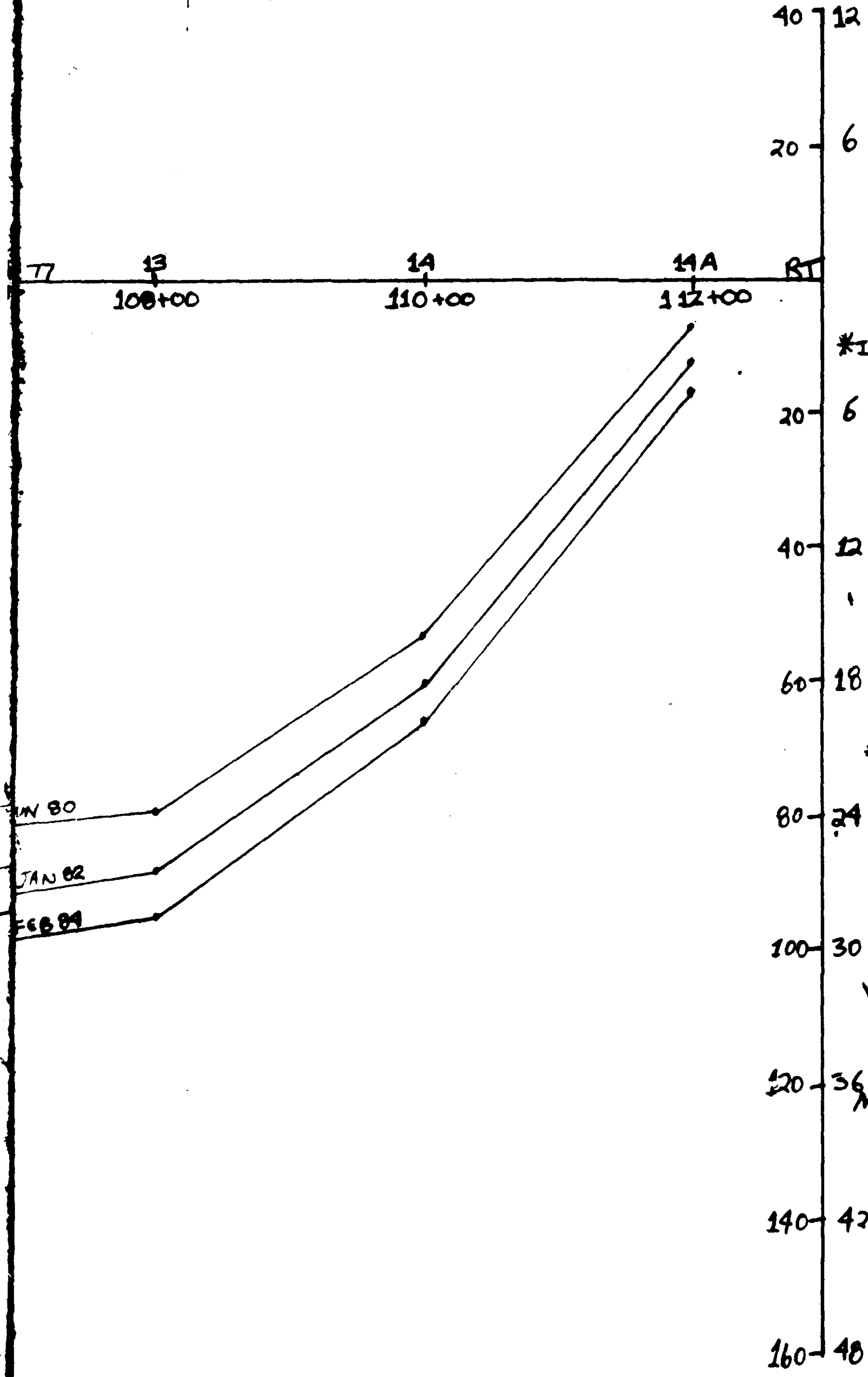
18' DOWNSTREAM

HORIZONTAL MOVEMENT

PLATE 52



UP
DOWN
VERTICAL CUMULATIVE MOVEMENT
(HUNDREDTHS OF A METRE)
(HUNDREDTHS OF A FOOT)
12
6
6
12
18
24
30
36
42
48
40
20
20
40
60
80
100
120
140
160
LT
10
11
12
102+00
104+00
106+00
JUN 77
JUN 80
JAN 82
FEB 84



"ZERO" READINGS JUN 77	
MON. NO.	ELEV.
10	818.60
11	817.98
12	817.90
13	817.84
14	818.04
14A	818.14

*INTERMEDIATE READINGS
SEP 77, DEC 77, FEB 78
MAR 78, APR 78, MAY 78
JUN 78, JUL 78, AUG 78
OCT 78, FEB 79, MAR 79
APR 79, OCT 79, MAR 80
AUG 80, JAN 81, APR 81
JUN 82, JAN 83, MAY 83
FEB 86, SEP 86

*INTERMEDIATE READINGS WERE NOT PLOTTED BECAUSE NO SIGNIFICANT CHANGE WAS NOTED FROM PREVIOUS READINGS

WILLIAM H. HARSHA

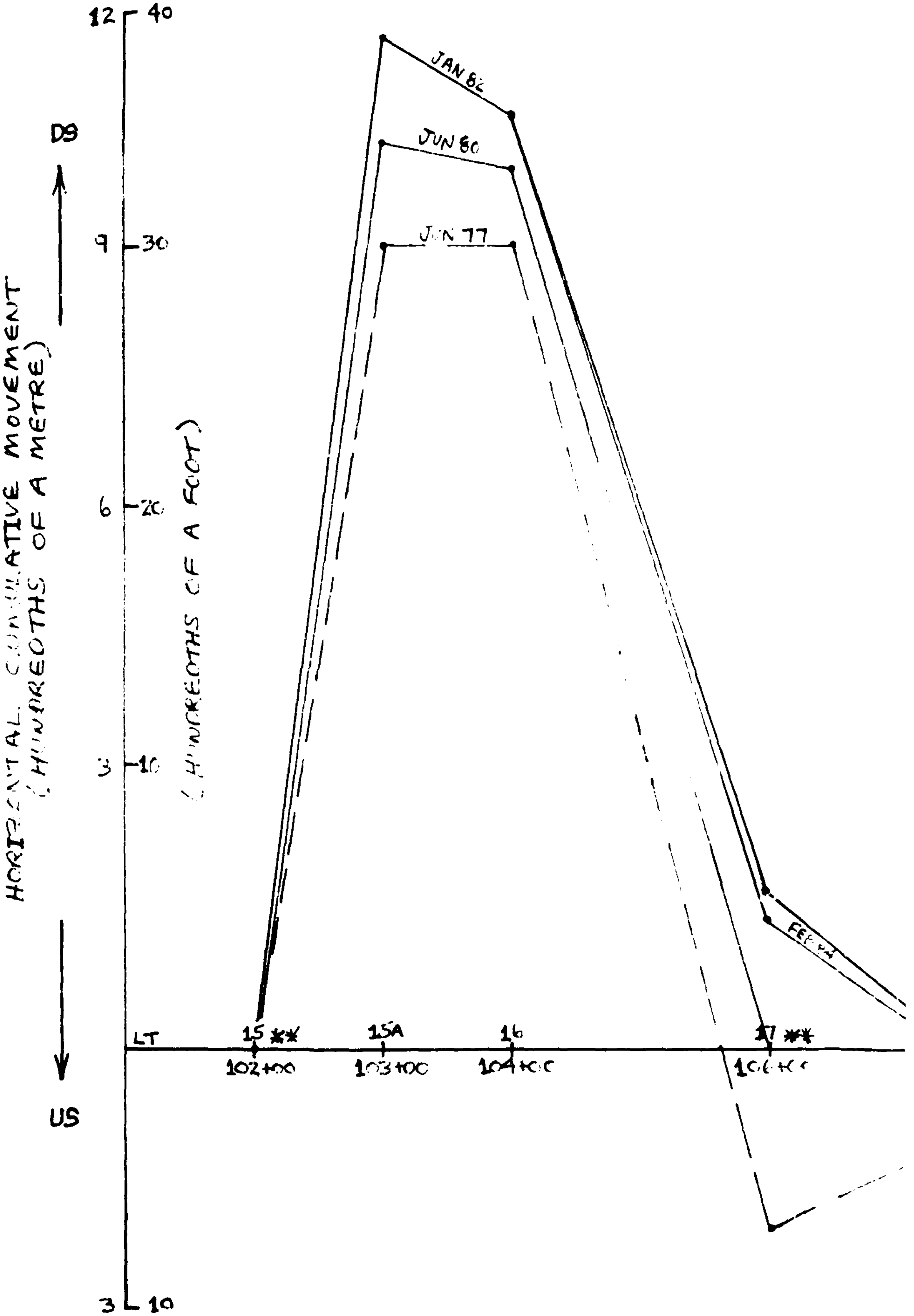
MAIN DAM

MOVEMENT MONUMENTS

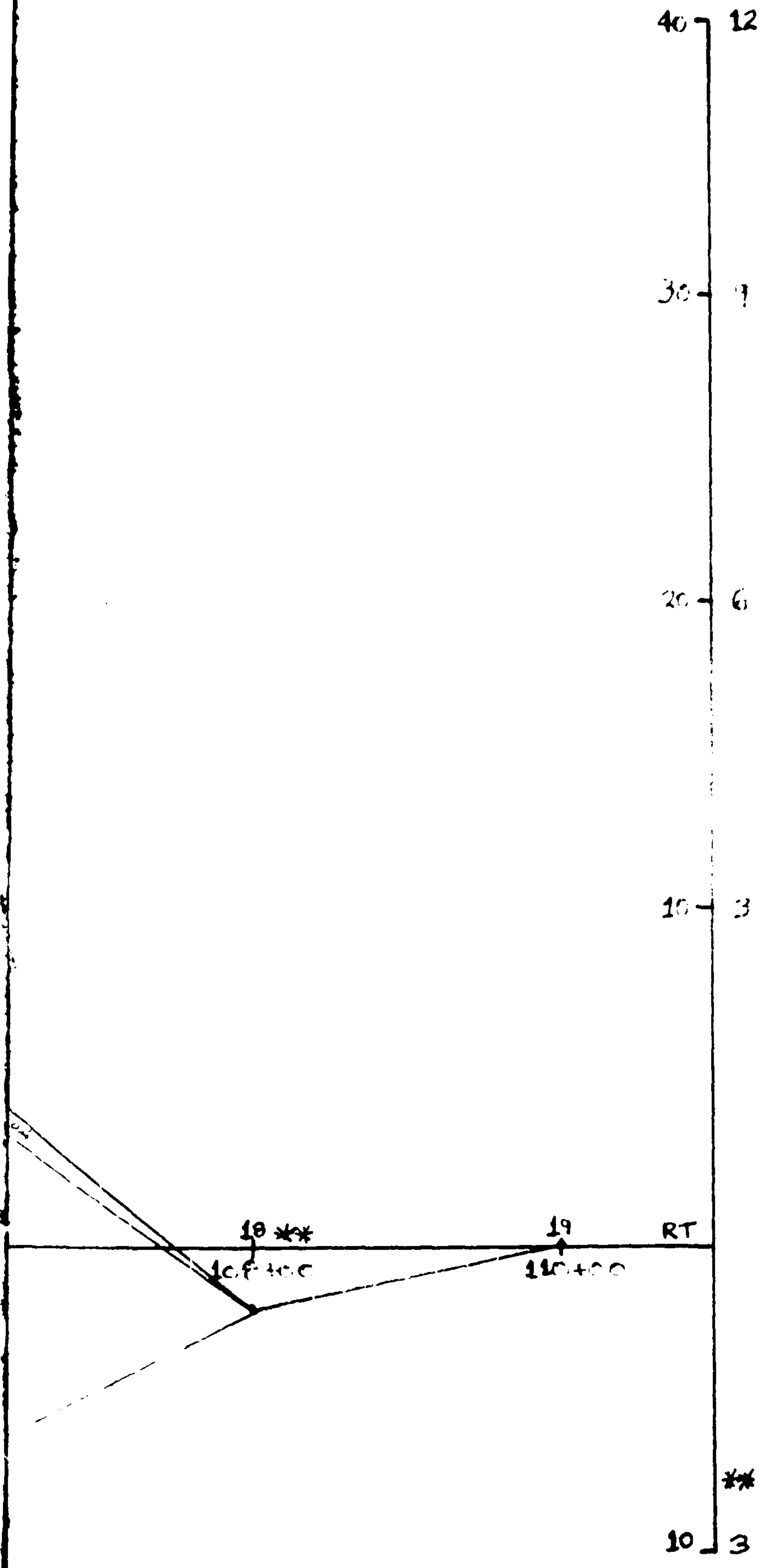
18' DOWNSTREAM

VERTICAL MOVEMENT

PLATE 53



HORIZONTAL CUMULATIVE MOVEMENT
(HUNDREDTHS OF A METRE)
(HUNDREDTHS OF A FOOT)
DS
US
12
9
6
3
3
40
30
20
10
10
JAN 82
JUN 80
JUN 77
FEB 84
LT
15 **
15A
16
17 **
102+00
103+00
104+00
106+00



INITIAL READINGS
JUN 77 ---

* INTERMEDIATE READINGS
FEB 78, MAR 78, APR 78
MAY 78, JUN 78, JUL 78
AUG 78, OCT 78, FEB 79
MAR 79, APR 79, OCT 79
MAR 80, AUG 80, JAN 81
APR 81, JUN 82, JAN 83
MAY 83, FEB 85, SEP 86

* INTERMEDIATE READINGS WERE NOT PLOTTED BECAUSE NO SIGNIFICANT CHANGE WAS NOTED FROM PREVIOUS READINGS

WILLIAM H. HARSHA LAKE

MAIN DAM

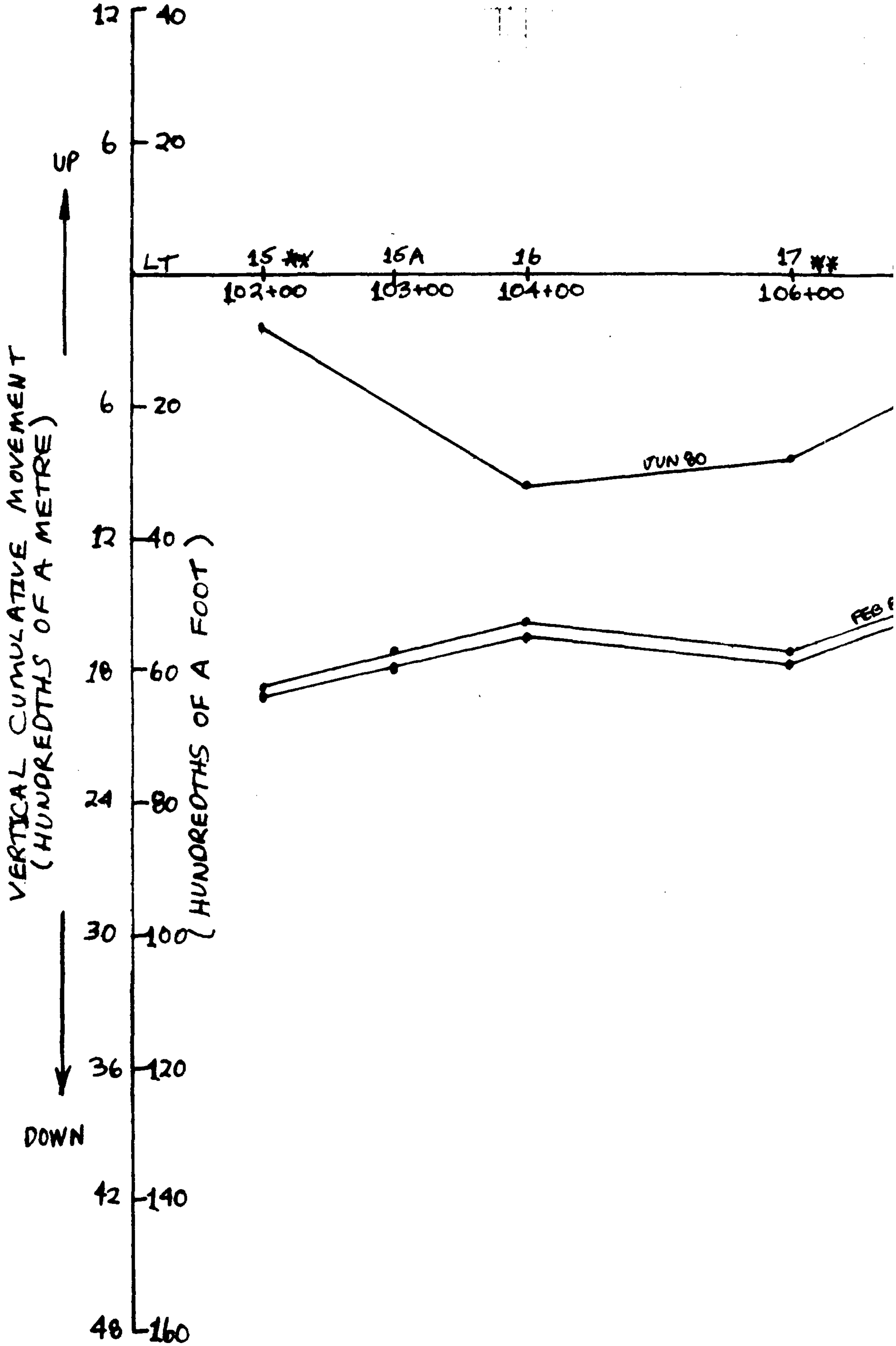
MOVEMENT MONUMENTS

320' DOWNSTREAM

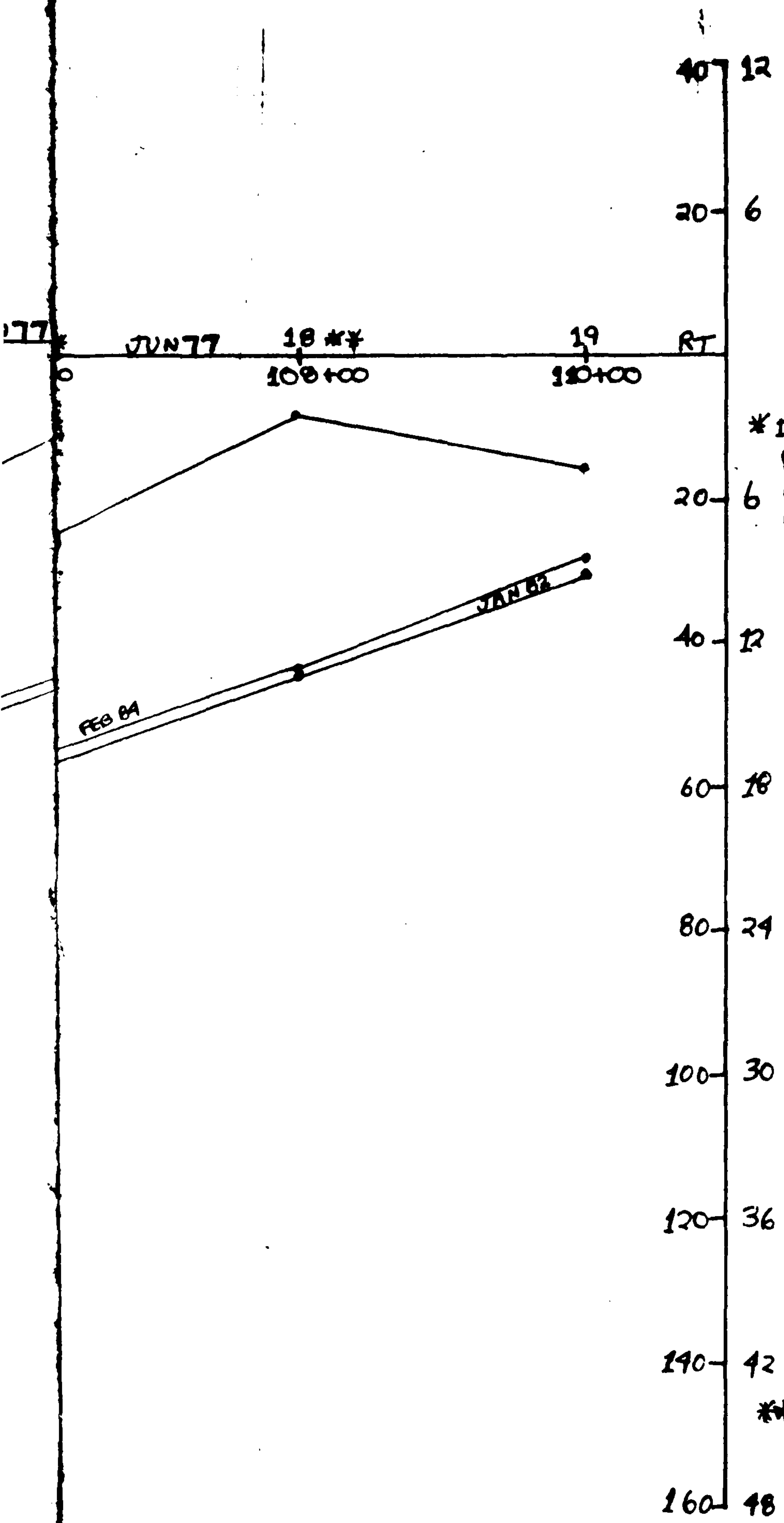
HORIZONTAL MOVEMENT

** MONUMENT RESET 1981

PLATE 54



VERTICAL CUMULATIVE MOVEMENT
(HUNDREDTHS OF A METRE)
(HUNDREDTHS OF A FOOT)
UP
DOWN
12
6
6
12
18
24
30
36
42
48
40
20
20
40
60
80
100
120
140
160
LT
15 **
16A
16
17 **
102+00
103+00
104+00
106+00
JUN 80



"ZERO" READINGS JUN 77	
MON. NO.	ELEV.
15	724.12
15A	724.43
16	726.10
17	726.27
18	726.69
19	726.97

* INTERMEDIATE READINGS
FEB 78, MAR 78, APR 78
MAY 78, JUN 78, JUL 78
AUG 78, OCT 78, FEB 79
MAR 79, APR 79, OCT 79
MAR 80, AUG 80, JAN 81
APR 81, JUN 82, JAN 83
MAY 83, FEB 85, SEP 86

* INTERMEDIATE READINGS WERE NOT PLOTTED BECAUSE NO SIGNIFICANT CHANGE WAS NOTED FROM PREVIOUS READINGS'

WILLIAM H. HARSHA LAKE

MAIN DAM

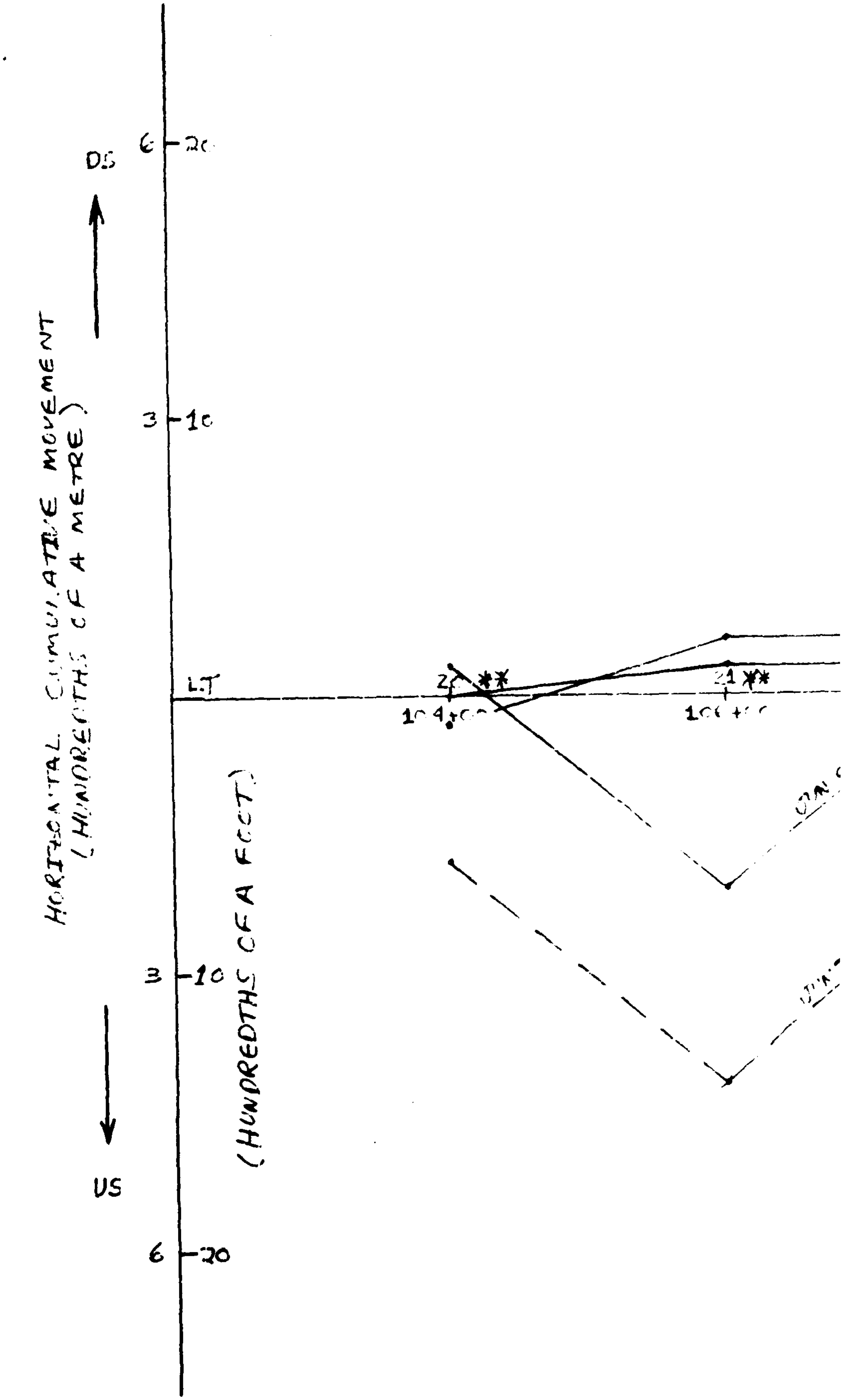
MOVEMENT MONUMENTS

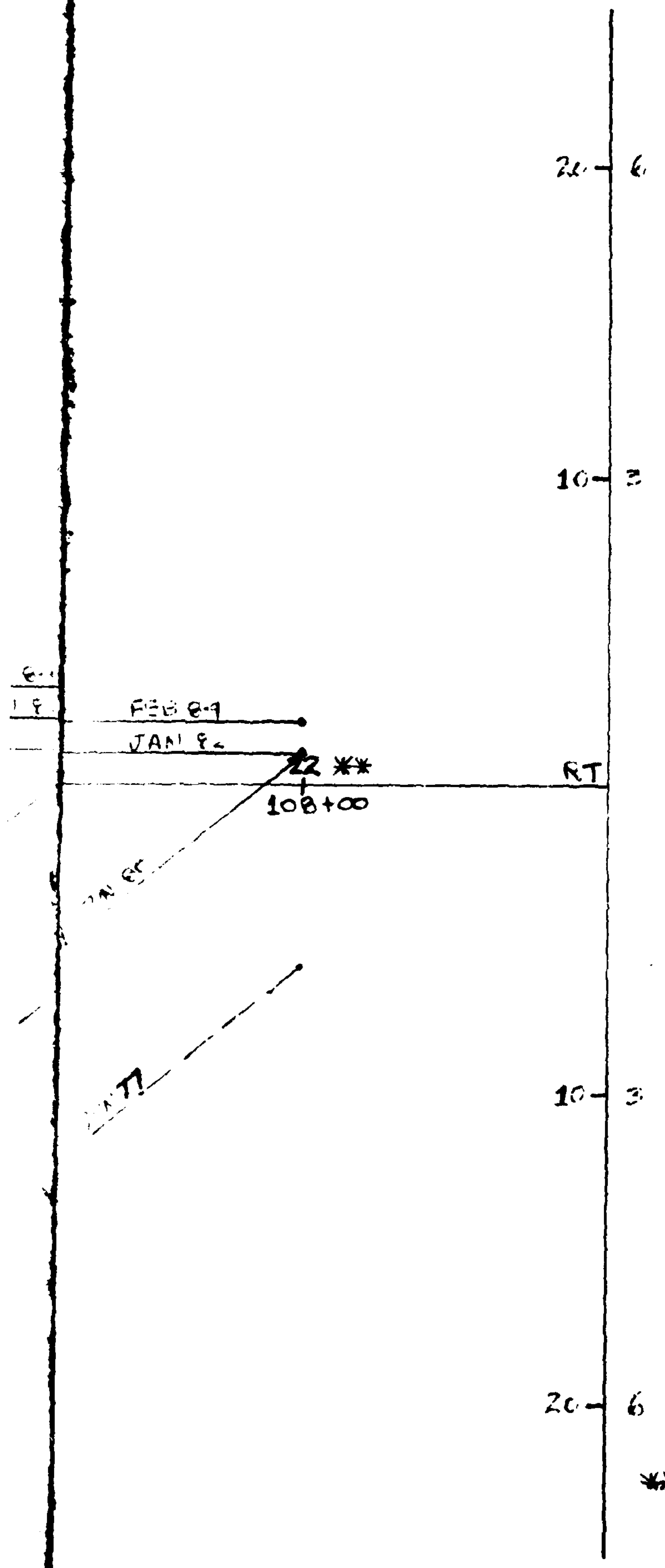
320' DOWNSTREAM

VERTICAL MOVEMENT

** MONUMENT RESET 1981

PLATE 55


HORIZONTAL CUMULATIVE MOVEMENT
(HUNDREDTHS OF A METRE)
(HUNDREDTHS OF A FOOT)
DS
US
6
3
3
6
20
10
10
20
LT
104+00
21 **



INITIAL READINGS
JUN 77 — — —

* INTERMEDIATE READINGS
FEB 78, MAR 78, APR 78
MAY 78, JUN 78, JUL 78
AUG 78, OCT 78, FEB 79
MAR 79, APR 79, OCT 79
MAR 80, AUG 80, JAN 81
APR 81, JUN 82, JAN 83
MAY 83, FEB 85, SEP 86

* INTERMEDIATE READINGS WERE NOT PLOTTED BECAUSE NO SIGNIFICANT CHANGE WAS NOTED FROM PREVIOUS READINGS

WILLIAM H. HARSHA LAKE

MAIN DAM

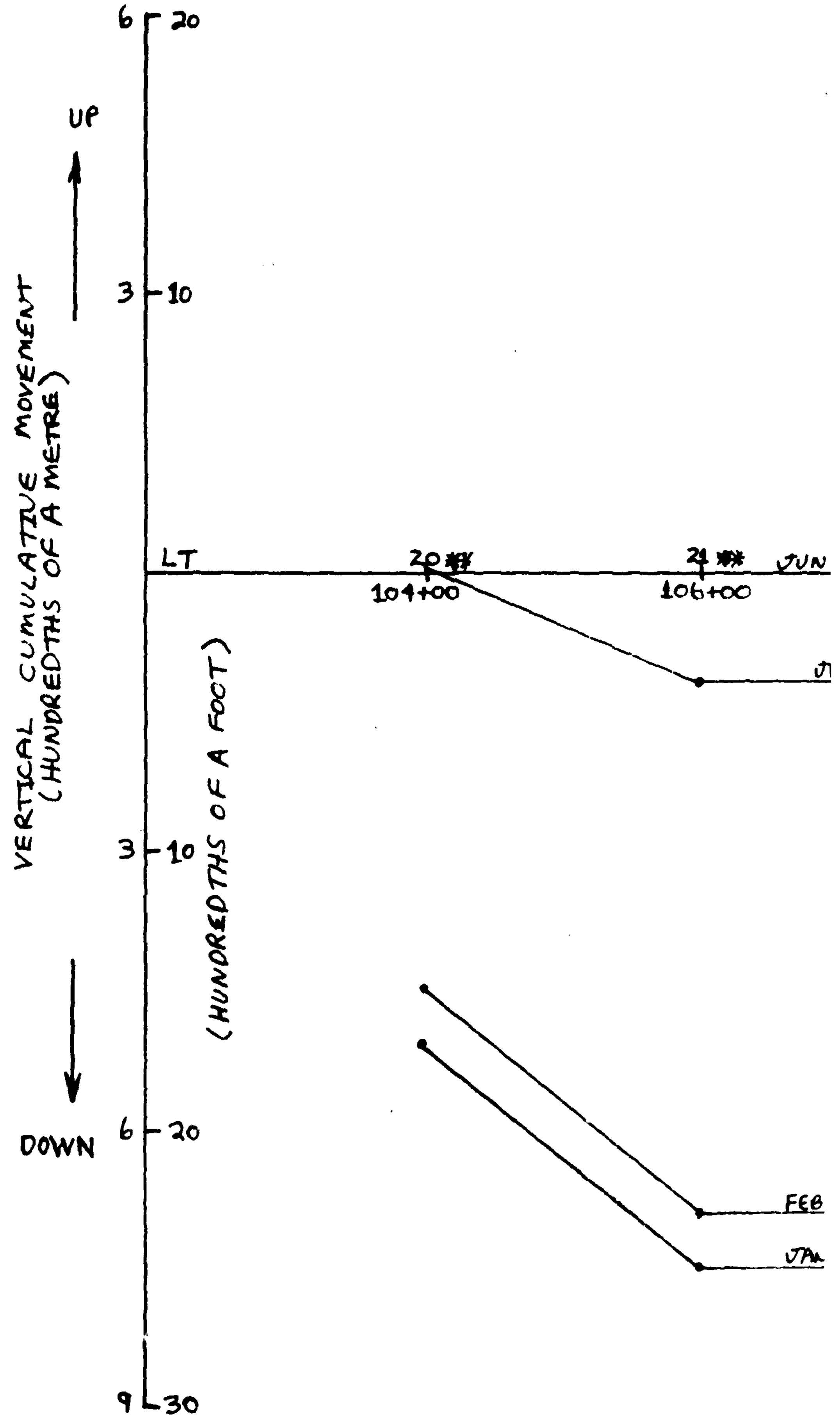
MOVEMENT MONUMENTS

695' DOWNSTREAM

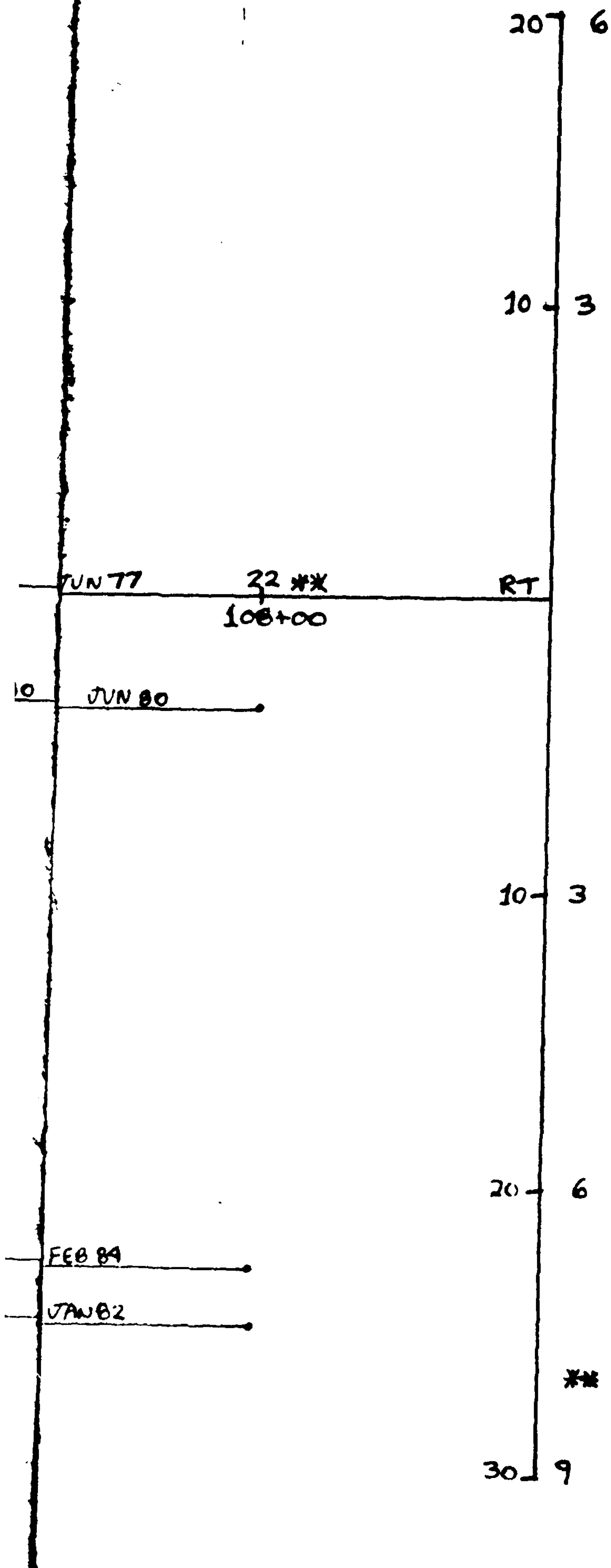
HORIZONTAL MOVEMENT

** MONUMENT RESET 1981

PLATE 56



UP
DOWN
VERTICAL CUMULATIVE MOVEMENT
(HUNDREDTHS OF A METRE)
(HUNDREDTHS OF A FOOT)
6
20
3
10
LT
3
10
6
20
9
30
20
104+00
21
106+00
JUN
FEB



"ZERO" READINGS
JUN 77

MON. NO.	ELEV.
20	649.79
21	650.54
22	650.65

* INTERMEDIATE READINGS
FEB 78, MAR 78, APR 78
MAY 78, JUN 78, JUL 78
AUG 78, OCT 78, FEB 79
MAR 79, APR 79, OCT 79
MAR 80, AUG 80, JAN 81
APR 81, JUN 82, JAN 83
MAY 83, FEB 85, SEP 86

* INTERMEDIATE READINGS WERE NOT PLOTTED BECAUSE NO SIGNIFICANT CHANGE WAS NOTED FROM PREVIOUS READINGS

WILLIAM H. HARSHA LAKE

MAIN DAM

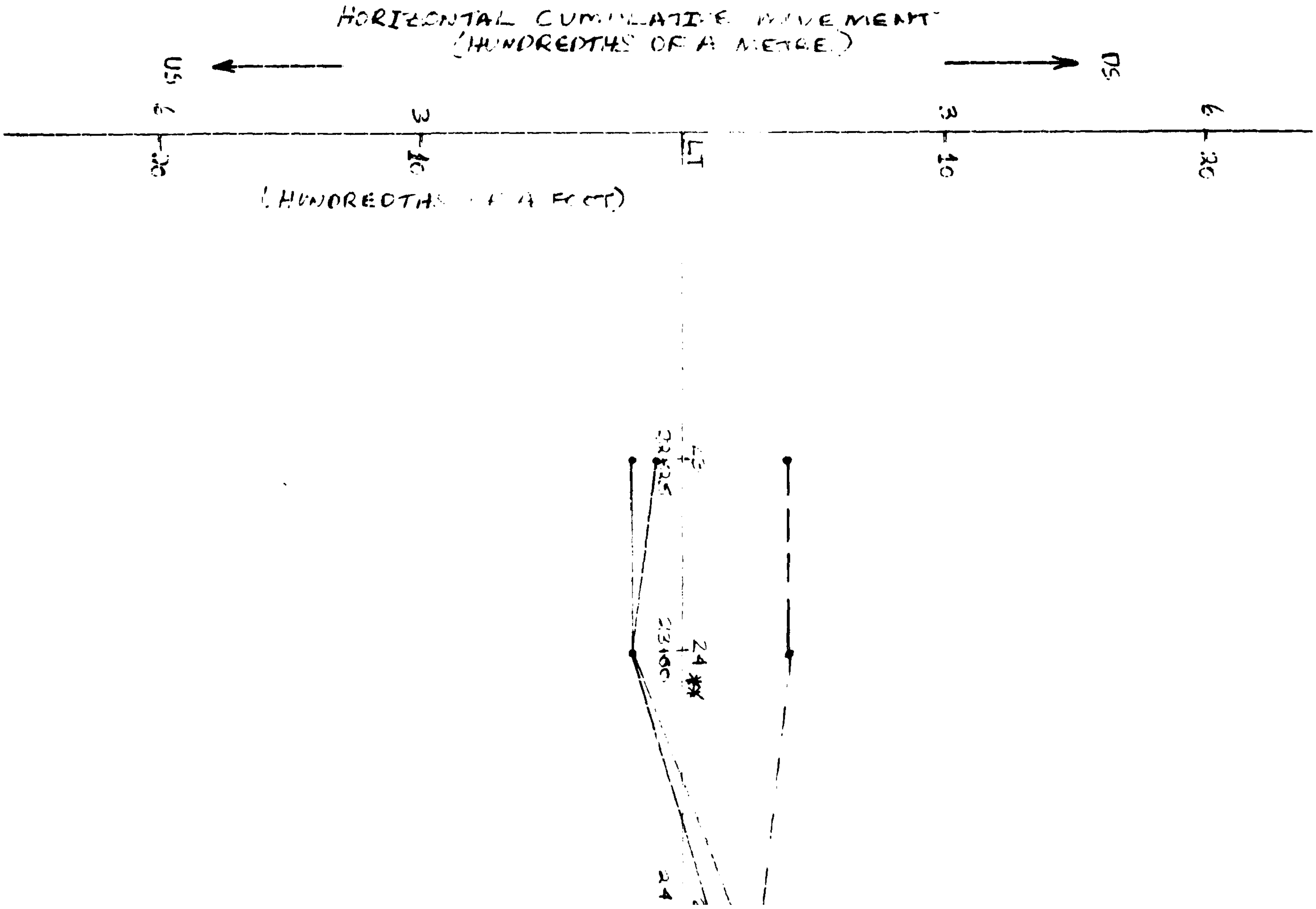
MOVEMENT MONUMENTS

695' DOWNSTREAM

VERTICAL MOVEMENT

** MONUMENT RESET 1981

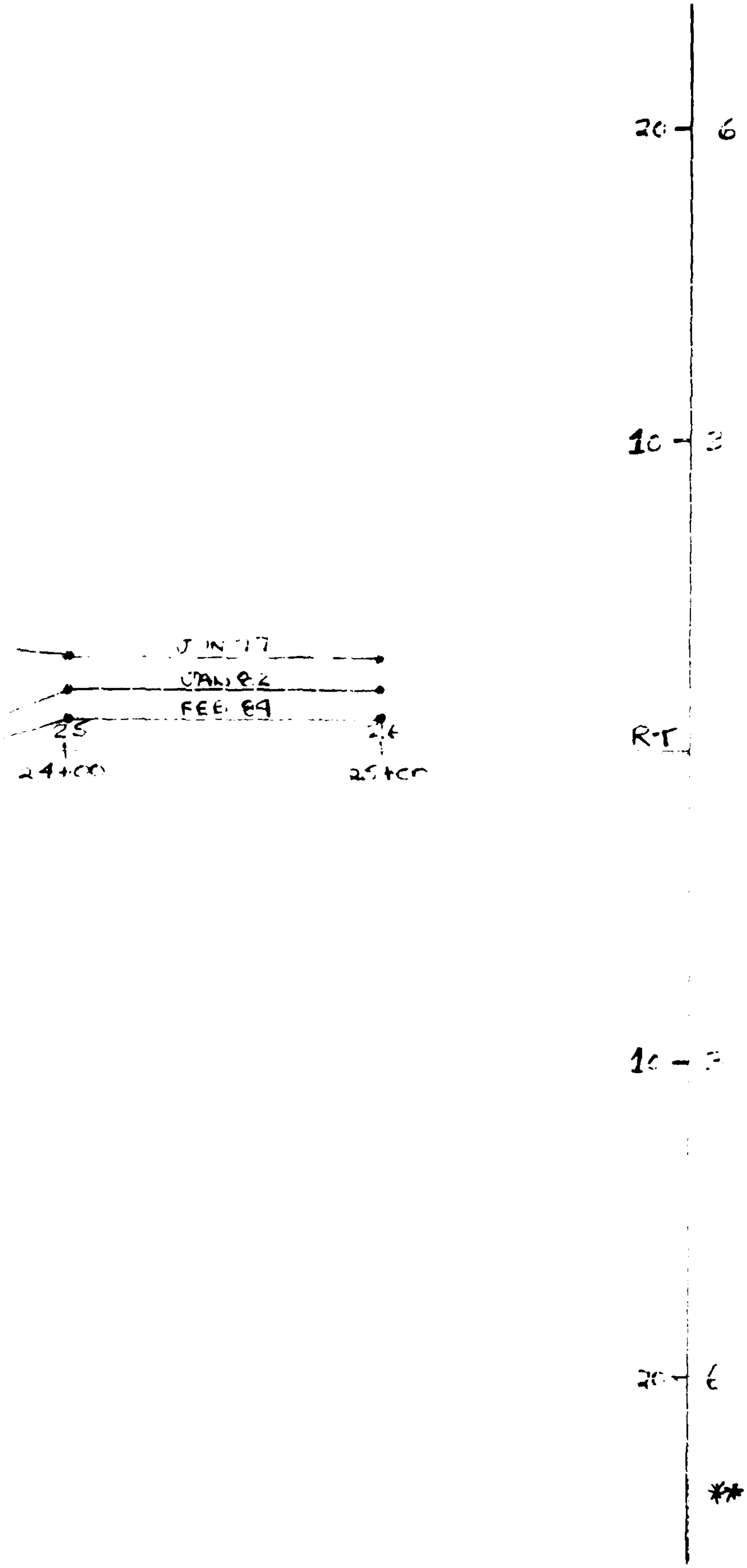
PLATE 57



HORIZONTAL CUMULATIVE MOVEMENT
(HUNDREDTHS OF A METRE)
US
DS
6
3
.20
.10
LT
(HUNDREDTHS OF A FOOT)
23+60
24

INITIAL READINGS
JUN 77 – – –

* INTERMEDIATE READINGS
MAR 78, APR 78, MAY 78
JUN 78, JUL 78, AUG 78
OCT 78, FEB 79, APR 79
OCT 79, MAR 80, AUG 80
JAN 81, JUN 82, JAN 83
JUN 83, FEB 85, SEP 86



* INTERMEDIATE READINGS WERE NOT PLOTTED BECAUSE NO SIGNIFICANT CHANGE WAS NOTED FROM PREVIOUS READINGS

WILLIAM H. HARSHA LAKE

SADDLE DAM

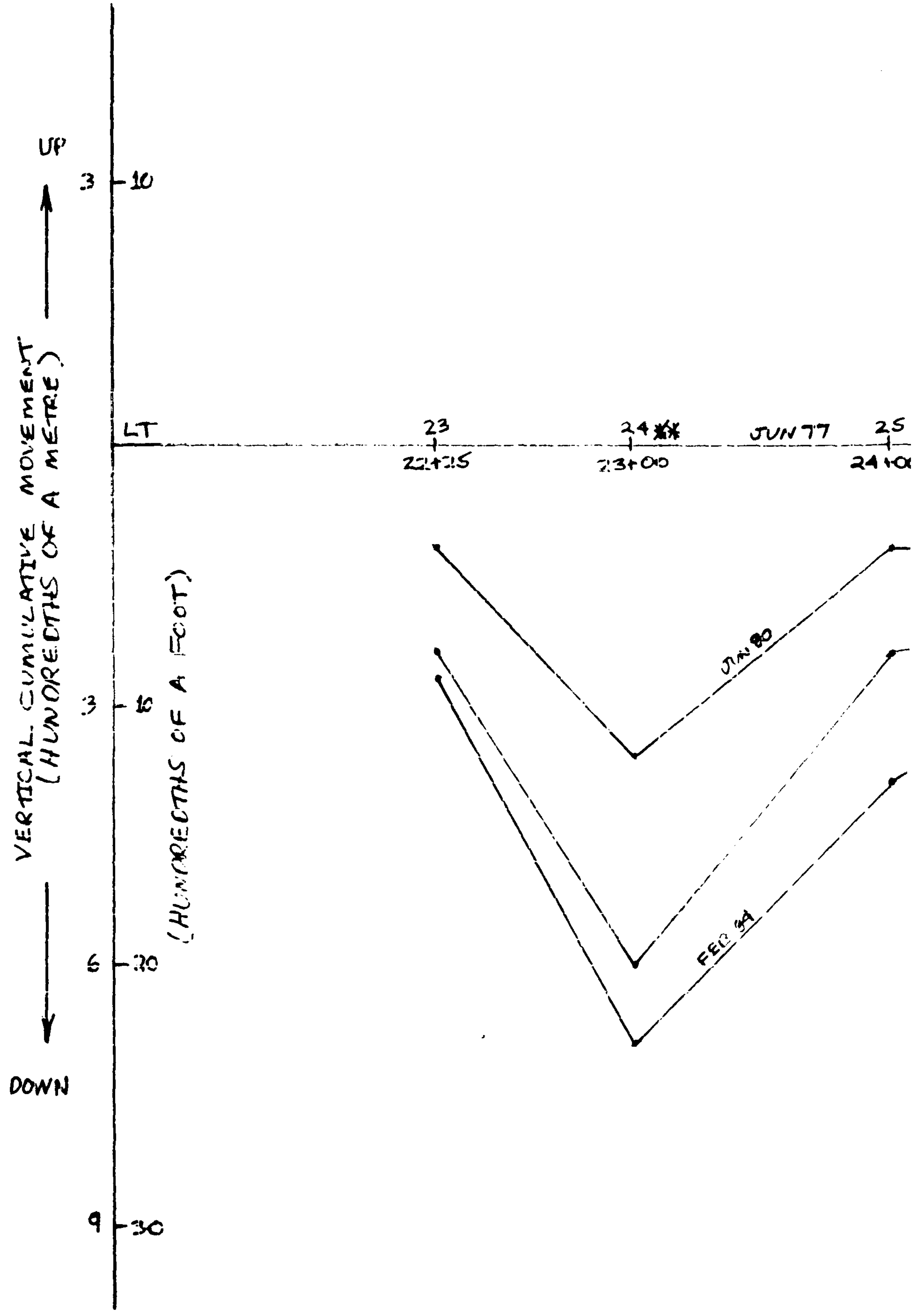
MOVEMENT MONUMENTS

340' UPSTREAM

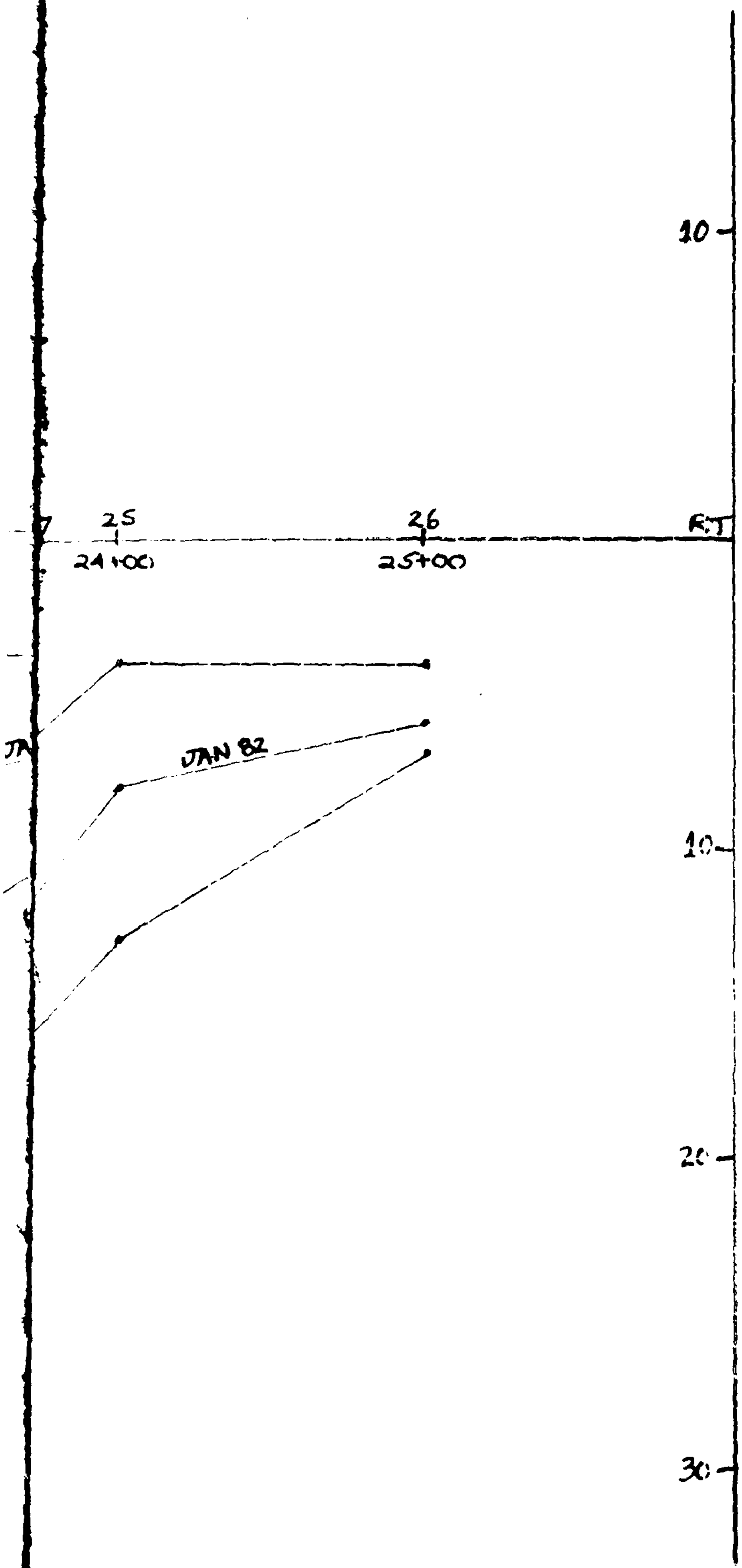
HORIZONTAL MOVEMENT

** MONUMENT RESET 1981

PLATE 58



UP
DOWN
VERTICAL CUMULATIVE MOVEMENT
(HUNDREDTHS OF A METRE)
(HUNDREDTHS OF A FOOT)
3
10
3
10
6
20
9
30
LT
23
22+25
24
23+00
JUN 77
25
24+00
JUN 80
FEB 84



"ZERO" READINGS JUN 77	
MON. NO.	ELEV.
23	736.34
24	735.36
25	736.53
26	736.18

* INTERMEDIATE READINGS
MAR 78, APR 78, MAY 78
JUN 78, JUL 78, AUG 78
OCT 78, FEB 79, APR 79
OCT 79, MAR 80, AUG 80
JAN 81, JUN 82, JAN 83
JUN 83, FEB 85, SEP 86

* INTERMEDIATE READINGS WERE NOT PLOTTED BECAUSE NO SIGNIFICANT CHANGE WAS NOTED FROM PREVIOUS READINGS

WILLIAM H. HARSHA LAKE

SADDLE DAM

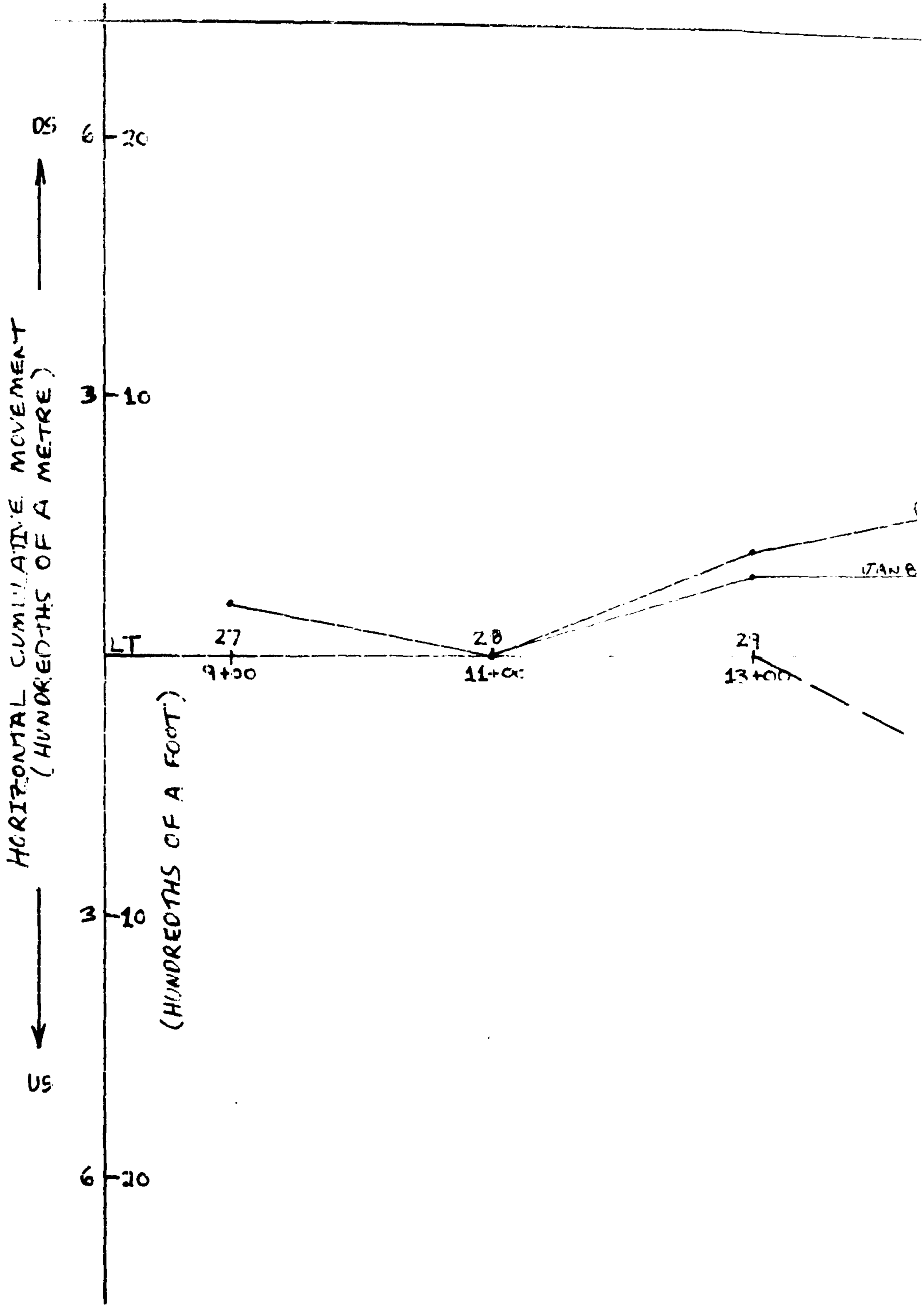
MOVEMENT MONUMENTS

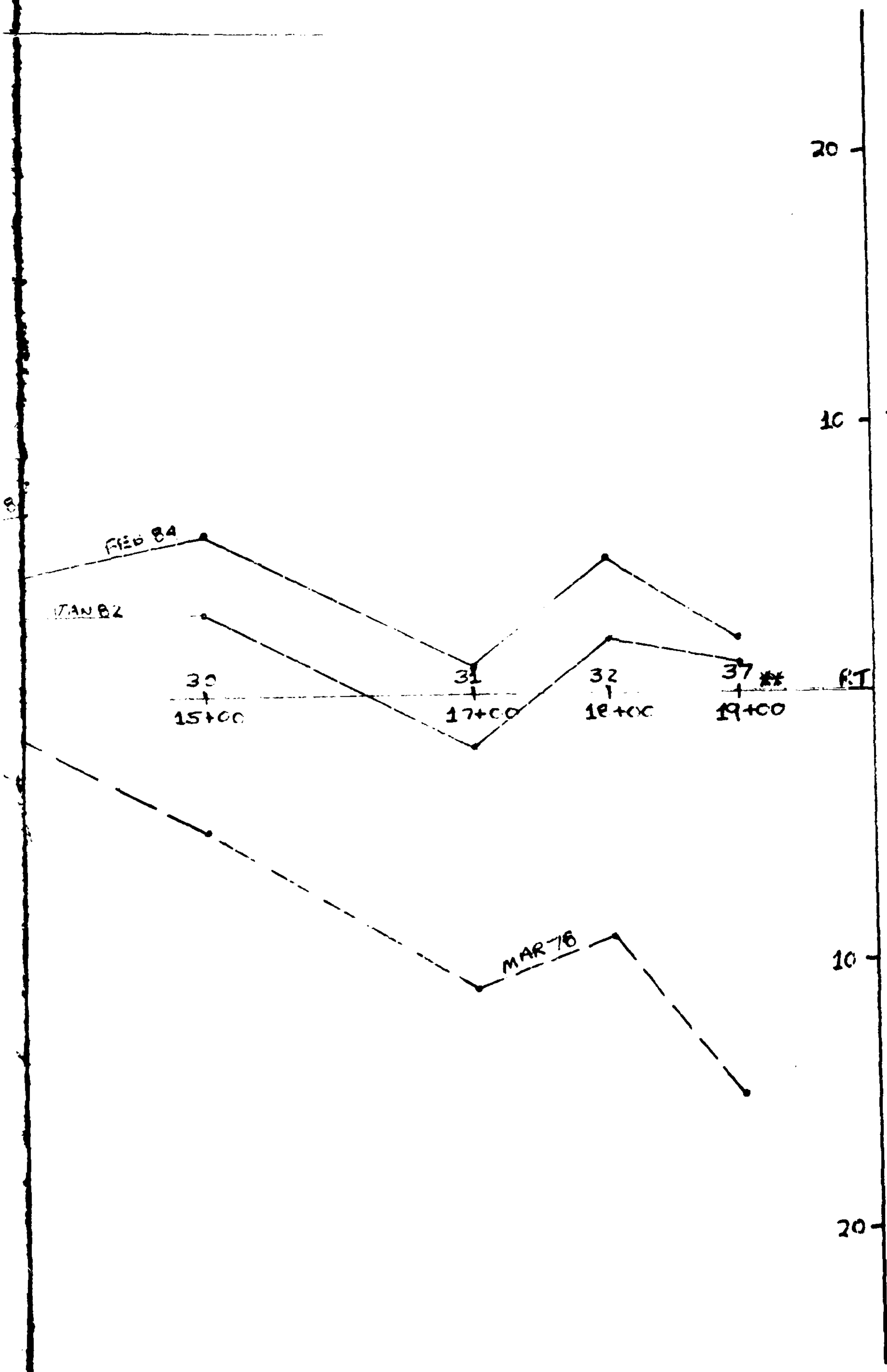
340' UPSTREAM

VERTICAL MOVEMENT

** MONUMENT RESET 1981

PLATE 59


DS
US
HORIZONTAL CUMULATIVE MOVEMENT
(HUNDREDTHS OF A METRE)
(HUNDREDTHS OF A FOOT)
6
20
3
10
3
10
6
20
LT
27
9+00
28
11+00
29
13+00
JAN 8



INITIAL READINGS
MAR 78 ---

*INTERMEDIATE READINGS
APR 78, MAY 78
JUN 78, JUL 78
AUG 78, OCT 78
FEB 79, APR 79
JUN 82, JAN 83
JUN 83, FEB 85
SEP 86

6

3

* INTERMEDIATE READINGS WERE NOT PLOTTED BECAUSE NO SIGNIFICANT CHANGE WAS NOTED FROM PREVIOUS READINGS

3

WILLIAM H. HARSHA

SADDLE DAM

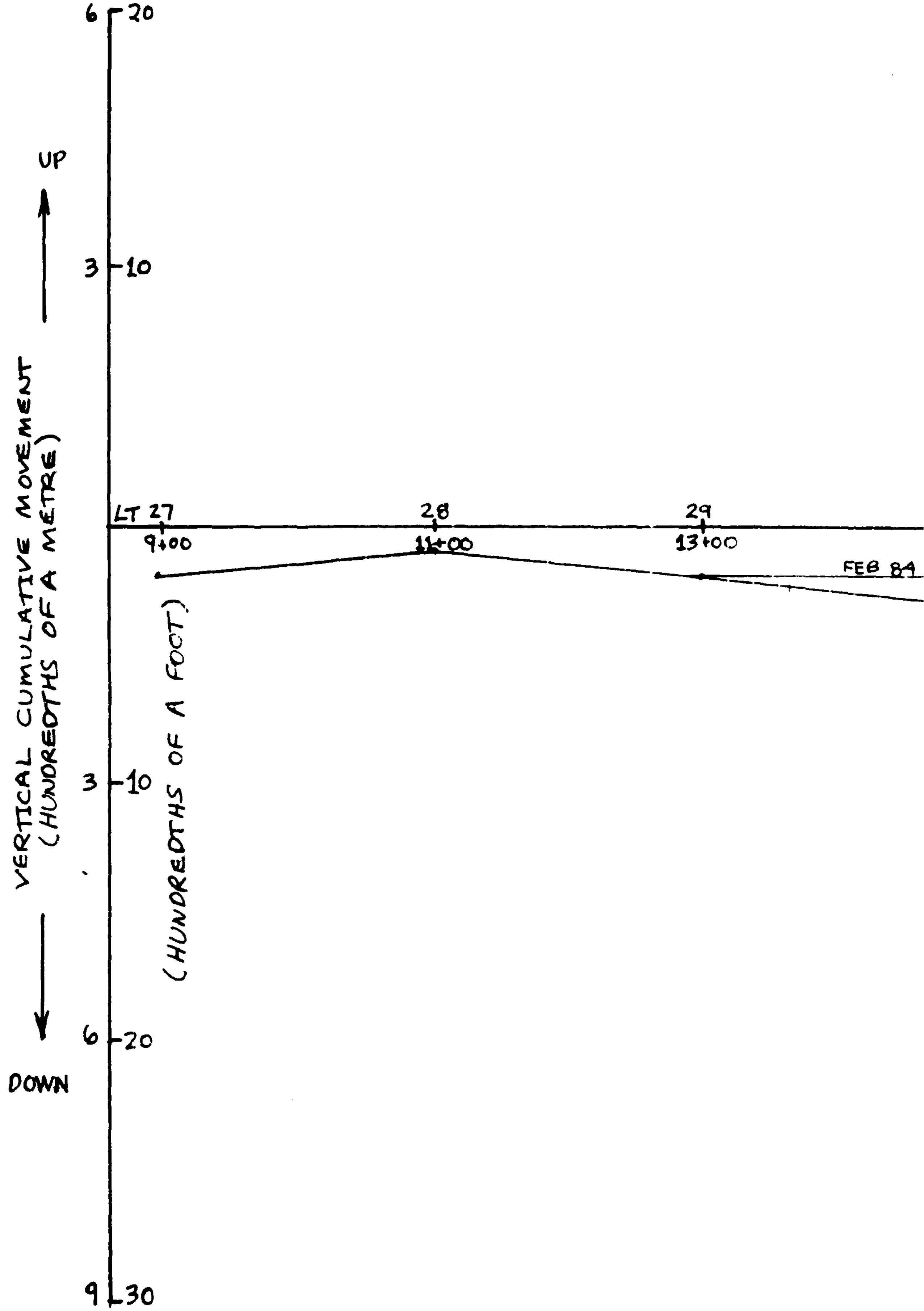
MOVEMENT MONUMENTS

6-200' DOWNSTREAM

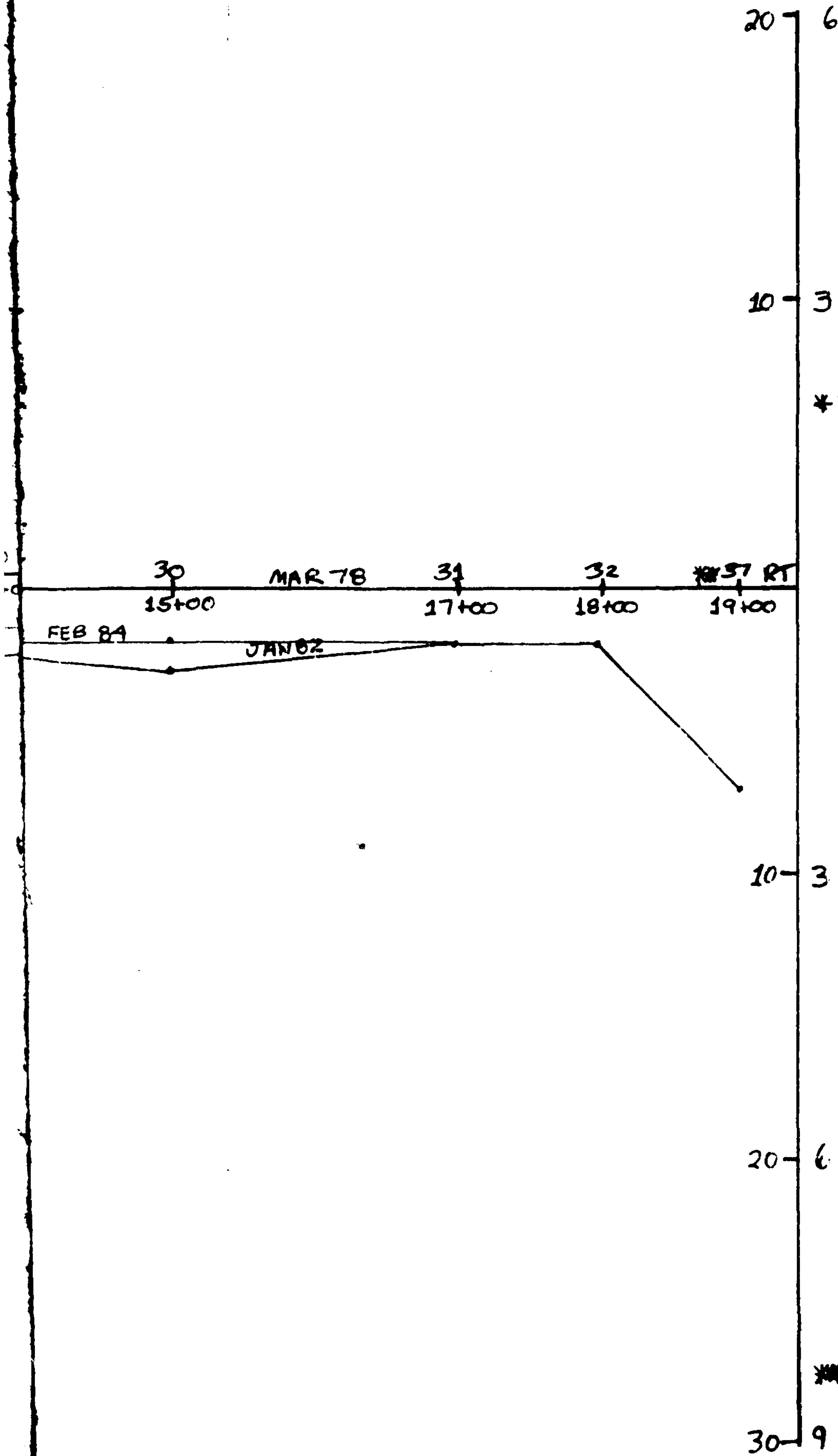
6 HORIZONTAL MOVEMENT

** MONUMENT RESET 1981

PLATE 60



UP
DOWN
VERTICAL CUMULATIVE MOVEMENT
(HUNDREDTHS OF A METRE)
(HUNDREDTHS OF A FOOT)
6
3
3
6
9
20
10
10
20
30
LT 27
9+00
28
11+00
29
13+00
FEB 84



"ZERO" READINGS
MAR 78

MON. NO.	ELEV.
27	819.30
28	819.33
29	805.48
30	788.39
31	772.93
32	764.64
37	755.08

*INTERMEDIATE READINGS

APR 78, MAY 78, JUN 78
JUL 78, AUG 78, OCT 78
FEB 79, APR 79, JUN 82
JAN 83, JUN 83, FEB 85
SEP 86

* INTERMEDIATE READINGS WERE NOT PLOTTED BECAUSE NO SIGNIFICANT CHANGE WAS NOTED FROM PREVIOUS READINGS

WILLIAM H. HARSHA LAKE

SADDLE DAM

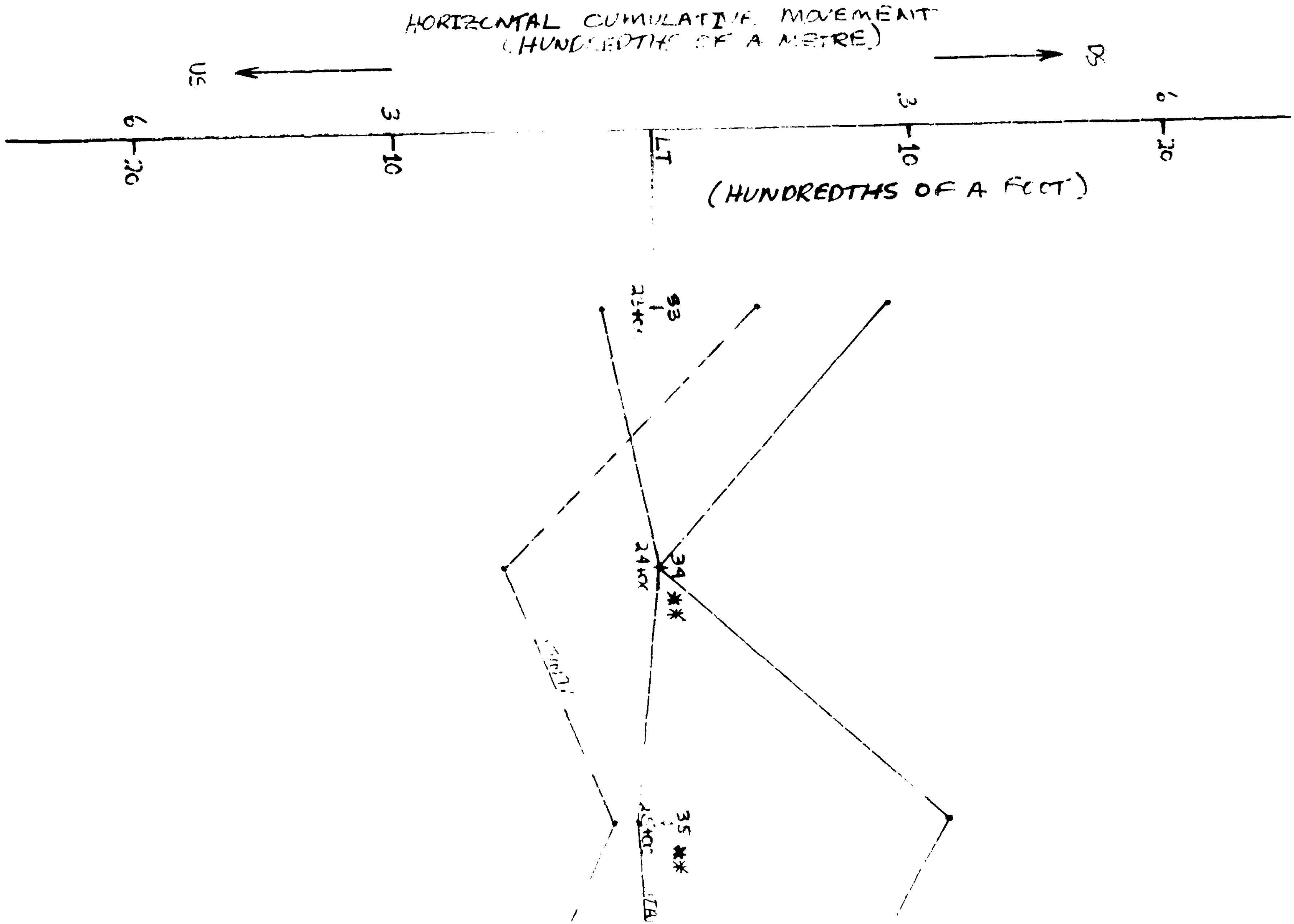
MOVEMENT MONUMENTS

6-200' DOWNSTREAM

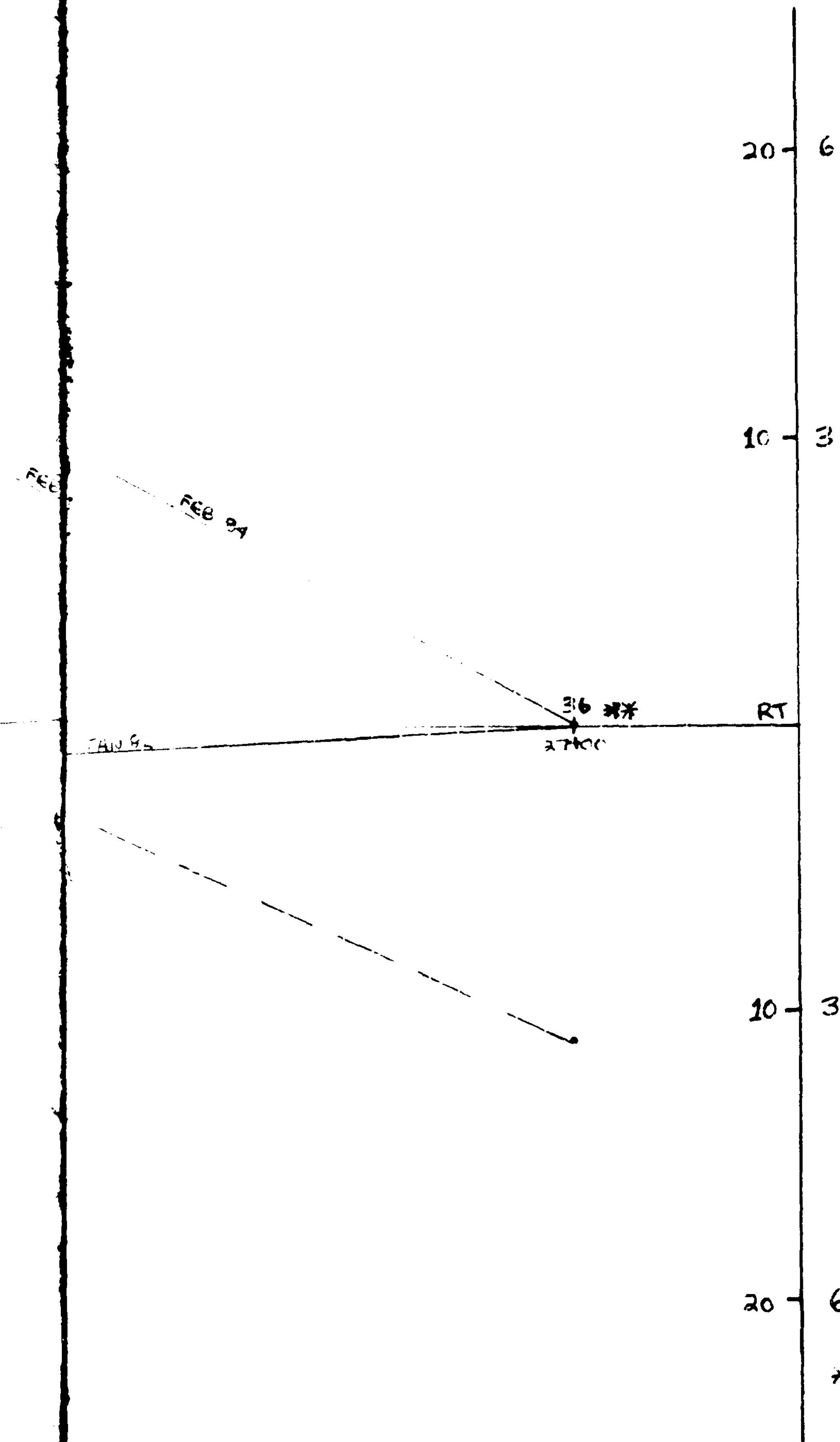
VERTICAL MOVEMENT

** MONUMENT RESET 1981

PLATE 61



HORIZONTAL CUMULATIVE MOVEMENT
(HUNDREDTHS OF A METRE)
US
DS
6
3
.3
6
20
10
LT
10
20
(HUNDREDTHS OF A FOOT)
33
34 **
24+00
35 **



INITIAL READINGS
JUN 77 ---

*INTERMEDIATE READINGS
MAR 78, APR 78, MAY 78
JUN 78, JUL 78, AUG 78
OCT 78, FEB 79, MAR 79
APR 79, OCT 79, MAR 80
AUG 80, JAN 81, JUN 82
JAN 83, JUN 83, FEB 85
SEP 86

* INTERMEDIATE READINGS WERE NOT PLOTTED BECAUSE NO SIGNIFICANT CHANGE WAS NOTED FROM PREVIOUS READINGS

WILLIAM H. HARSHA LAKE

SADDLE DAM 1

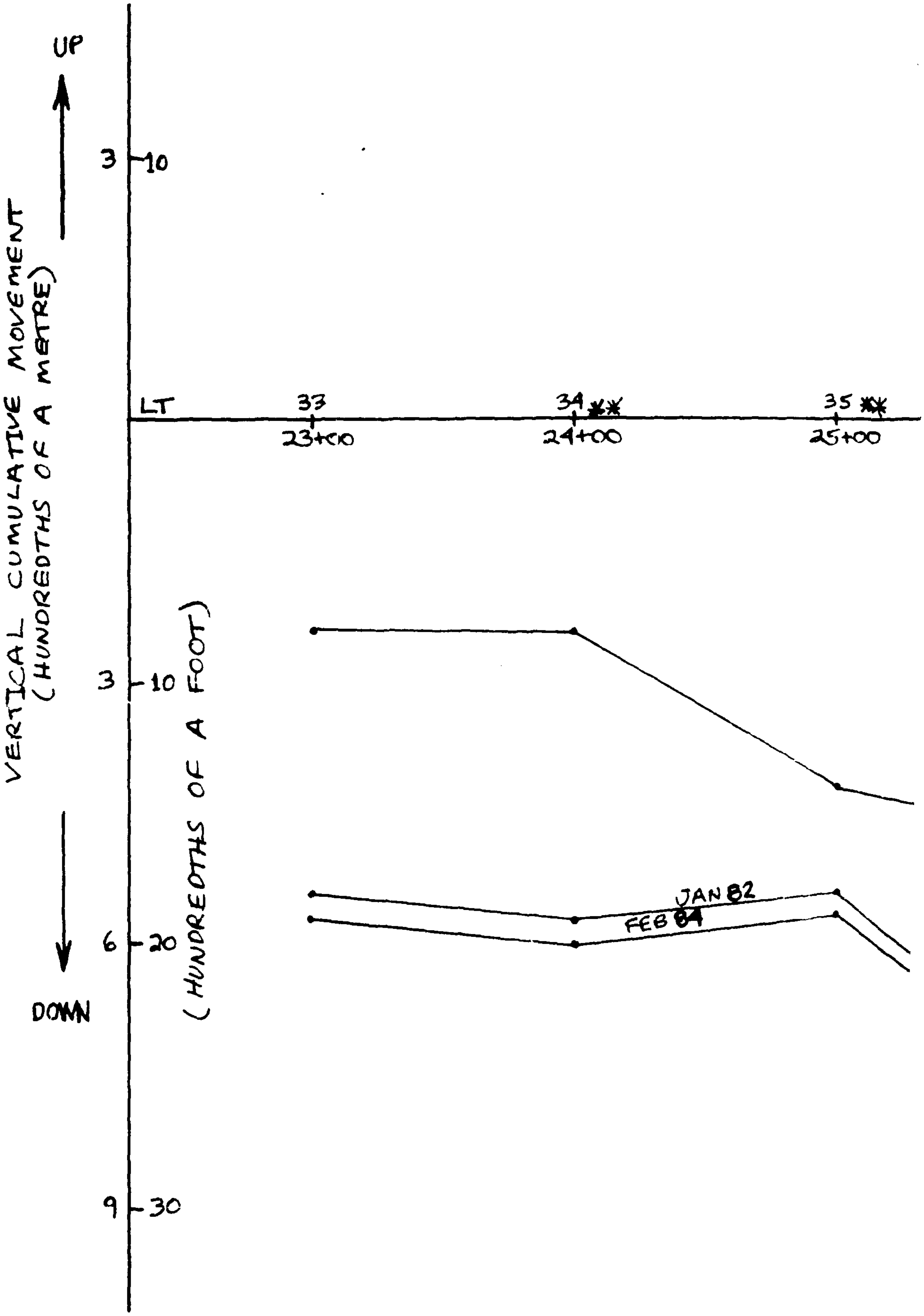
MOVEMENT MONUMENTS

38' DOWNSTREAM

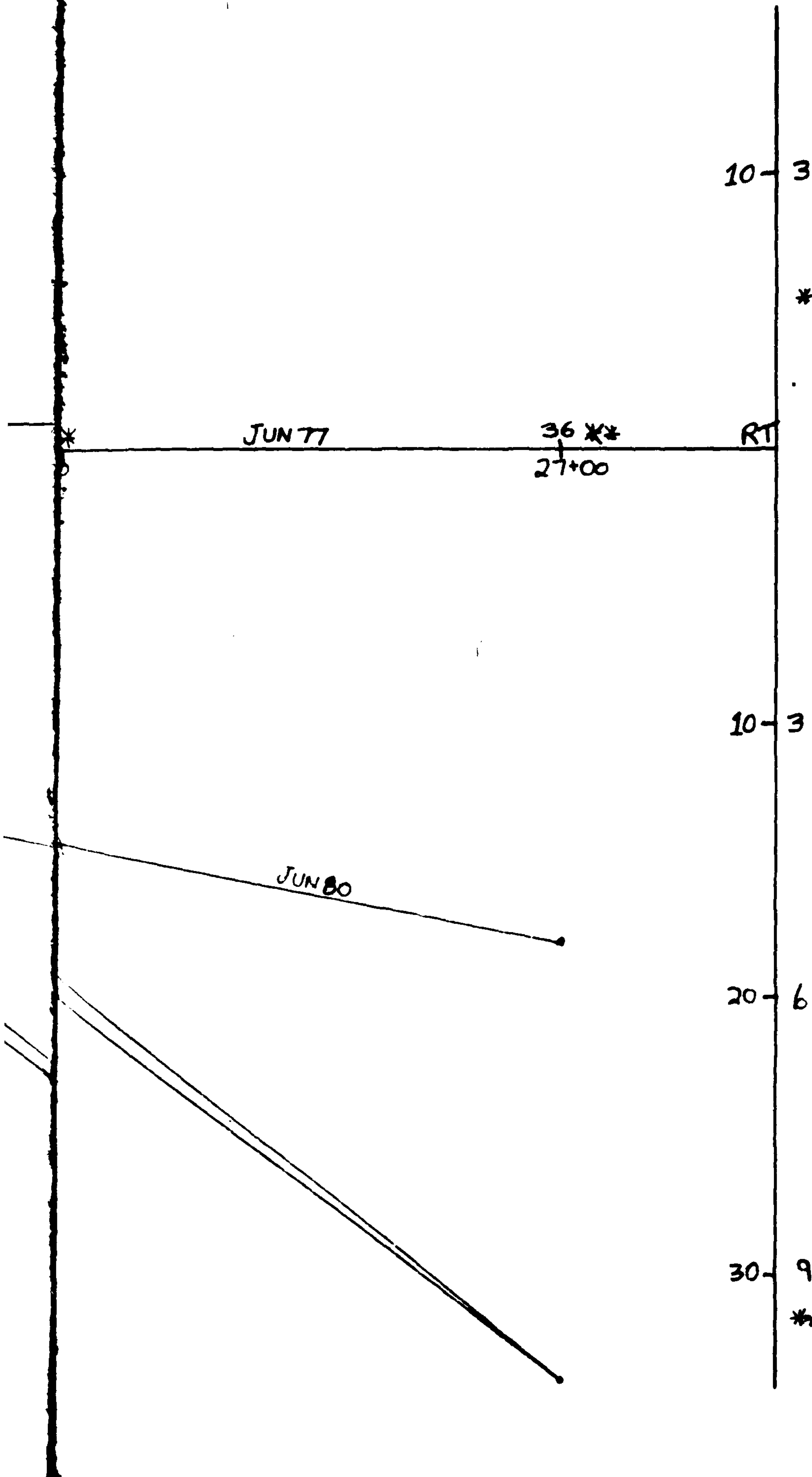
HORIZONTAL MOVEMENT

** MONUMENT RESET 1981

PLATE 62



UP
DOWN
VERTICAL CUMULATIVE MOVEMENT
(HUNDREDTHS OF A METRE)
(HUNDREDTHS OF A FOOT)
3
10
3
10
6
20
9
30
LT
33
34 **
35 **
23+00
24+00
25+00
JAN 82
FEB 84



"ZERO" READINGS JUN77	
MON. NO.	ELEV.
33	811.14
34	810.39
35	810.23
36	811.06

*INTERMEDIATE READINGS MAR 78, APR 78, MAY 78 JUN 78, JUL 78, AUG 78 OCT 78, FEB 79, MAR 79 APR 79, OCT 79, MAR 80 AUG 80, JAN 81, JUN 82 JAN 83, JUN 83, FEB 85 SEP 86

* INTERMEDIATE READINGS WERE NOT PLOTTED BECAUSE NO SIGNIFICANT CHANGE WAS NOTED FROM PREVIOUS READINGS

WILLIAM H. HARSHA

SADDLE DAM

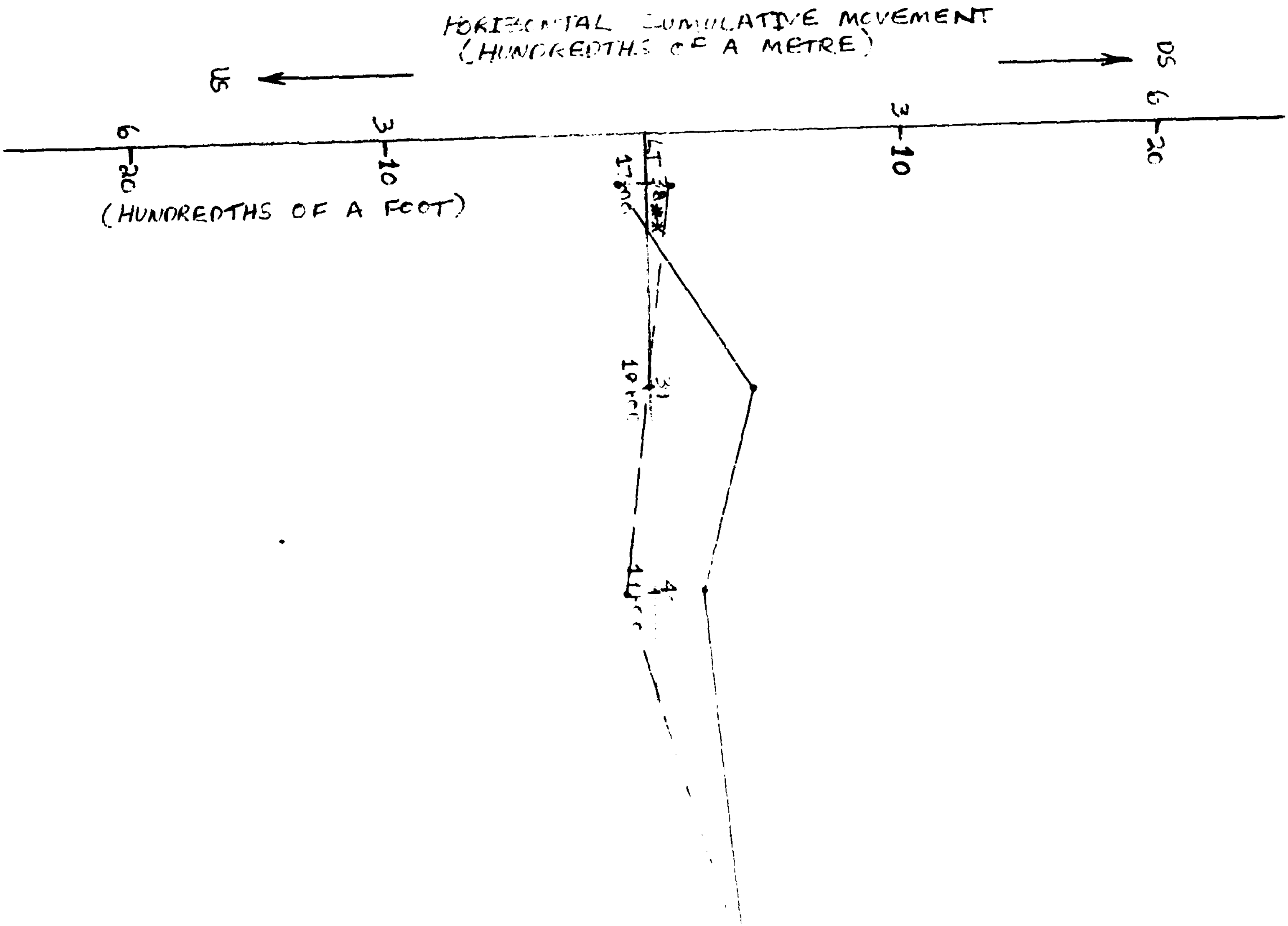
MOVEMENT MONUMENTS

38' DOWNSTREAM

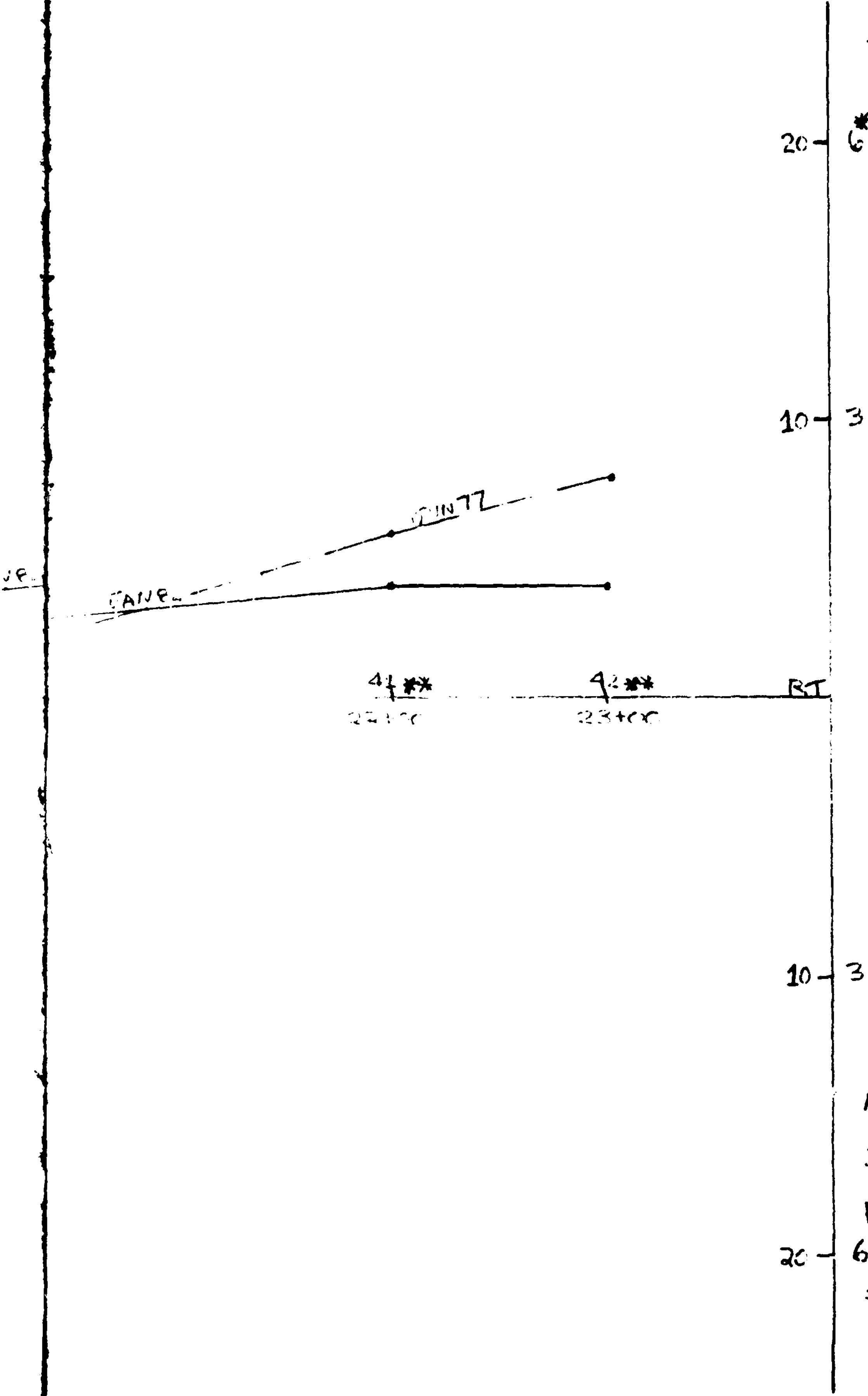
VERTICAL MOVEMENT

** MONUMENT RESET 1981

PLATE 63



HORIZONTAL CUMULATIVE MOVEMENT
(HUNDREDTHS OF A METRE)
US
DS
(HUNDREDTHS OF A FOOT)
6
20
3
10
3
10
6
20



INITIAL READINGS
JUN 77 ———

* INTERMEDIATE READINGS
JAN78, MAR78, APR 78
MAY78, JUN78, JUL 78
AUG78, OCT78, FEB79
MAR79, APR79, OCT79
MAR80, AUG80, FEB81
JAN83, FEB85, SEP86

* INTERMEDIATE READINGS
WERE NOT PLOTTED
BECAUSE NO SIGNIFICANT
CHANGE WAS NOTED
FROM PREVIOUS READINGS

WILLIAM H. HARSHA

SADDLE DAM

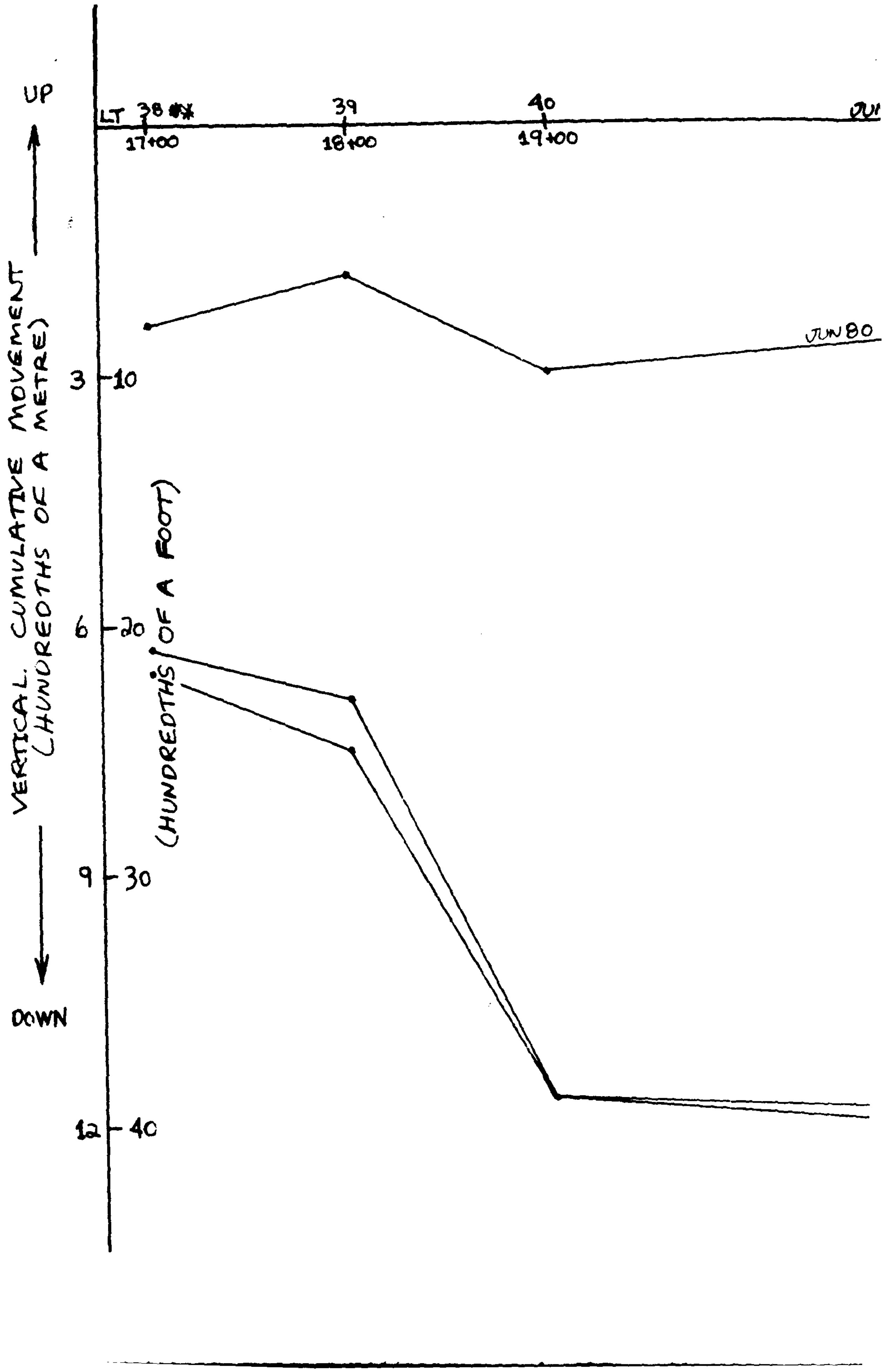
MOVEMENT MONUMENTS

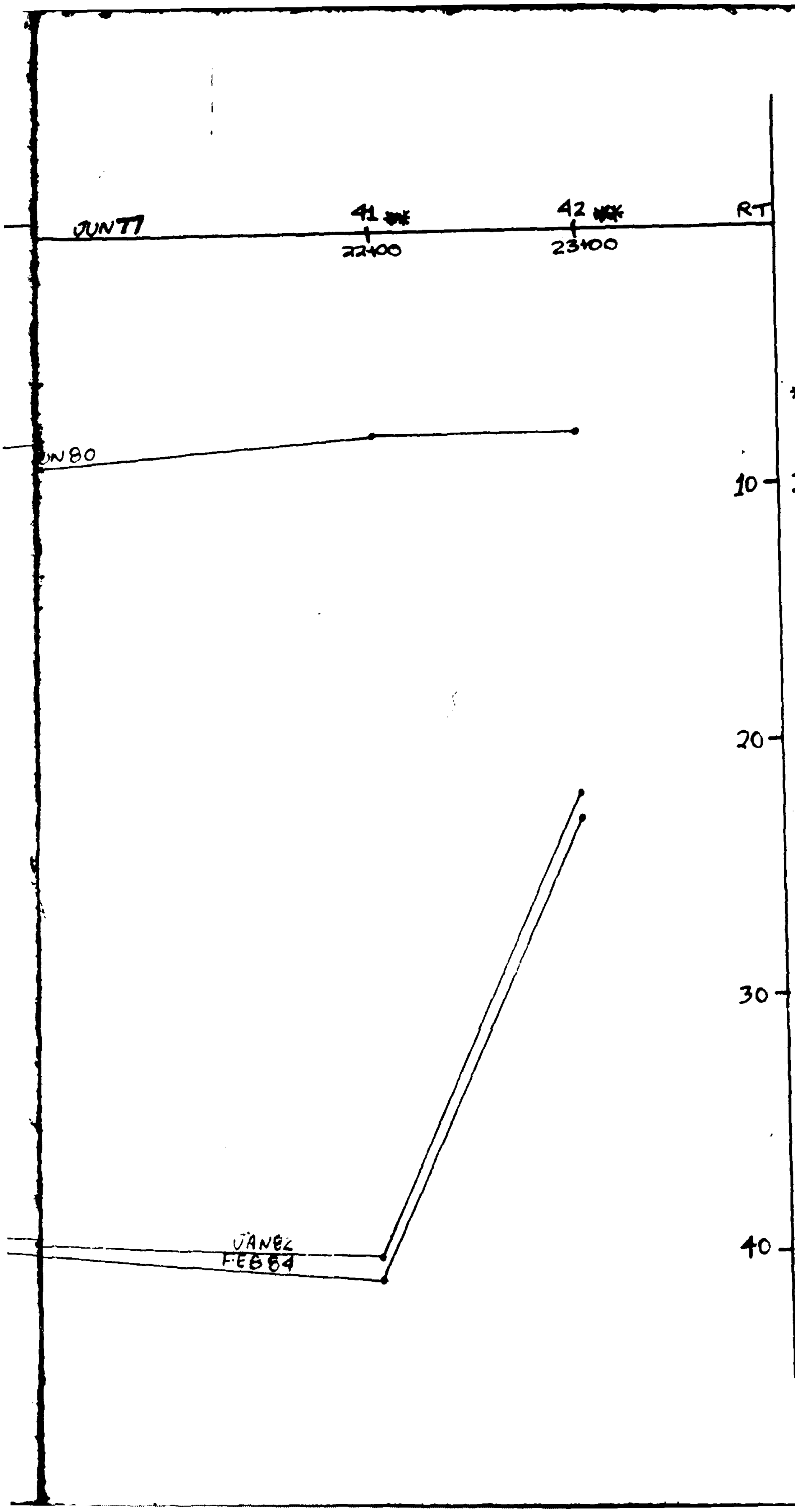
300-400' DOWNSTREAM

HORIZONTAL MOVEMENT

** MONUMENT RESET 1981

PLATE 64


UP
DOWN
VERTICAL CUMULATIVE MOVEMENT
(HUNDREDTHS OF A METRE)
(HUNDREDTHS OF A FOOT)
LT 38
39
40
17+00
18+00
19+00
JUN 80
3
6
9
12
10
20
30
40



"ZERO" READINGS JUN 77	
MON. NO.	ELEV.
38	738.49
39	741.18
40	742.38
41	744.17
42	746.34

✱ INTERMEDIATE READINGS
JAN78, MAR78, APR78
MAY78, JUN78, JUL78
AUG78, OCT78, FEB79
MAR79, APR79, OCT79
MAR80, AUG80, FEB81
JAN83, FEB85, SEP86

✱ INTERMEDIATE READINGS WERE NOT PLOTTED BECAUSE NO SIGNIFICANT CHANGE WAS NOTED FROM PREVIOUS READINGS

WILLIAM H. HARSHA

SADDLE DAM

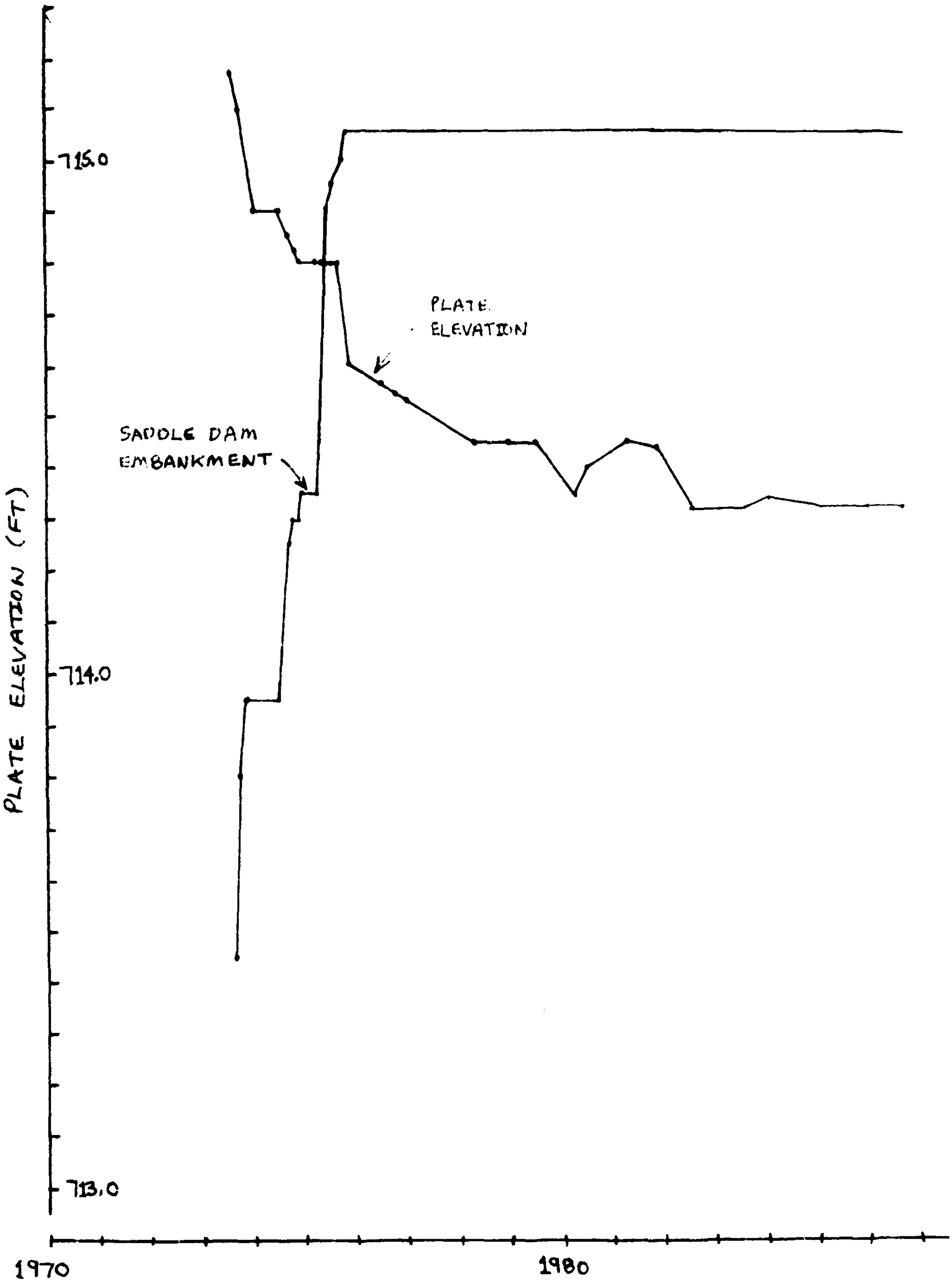
MOVEMENT MONUMENTS

300-400' DOWNSTREAM

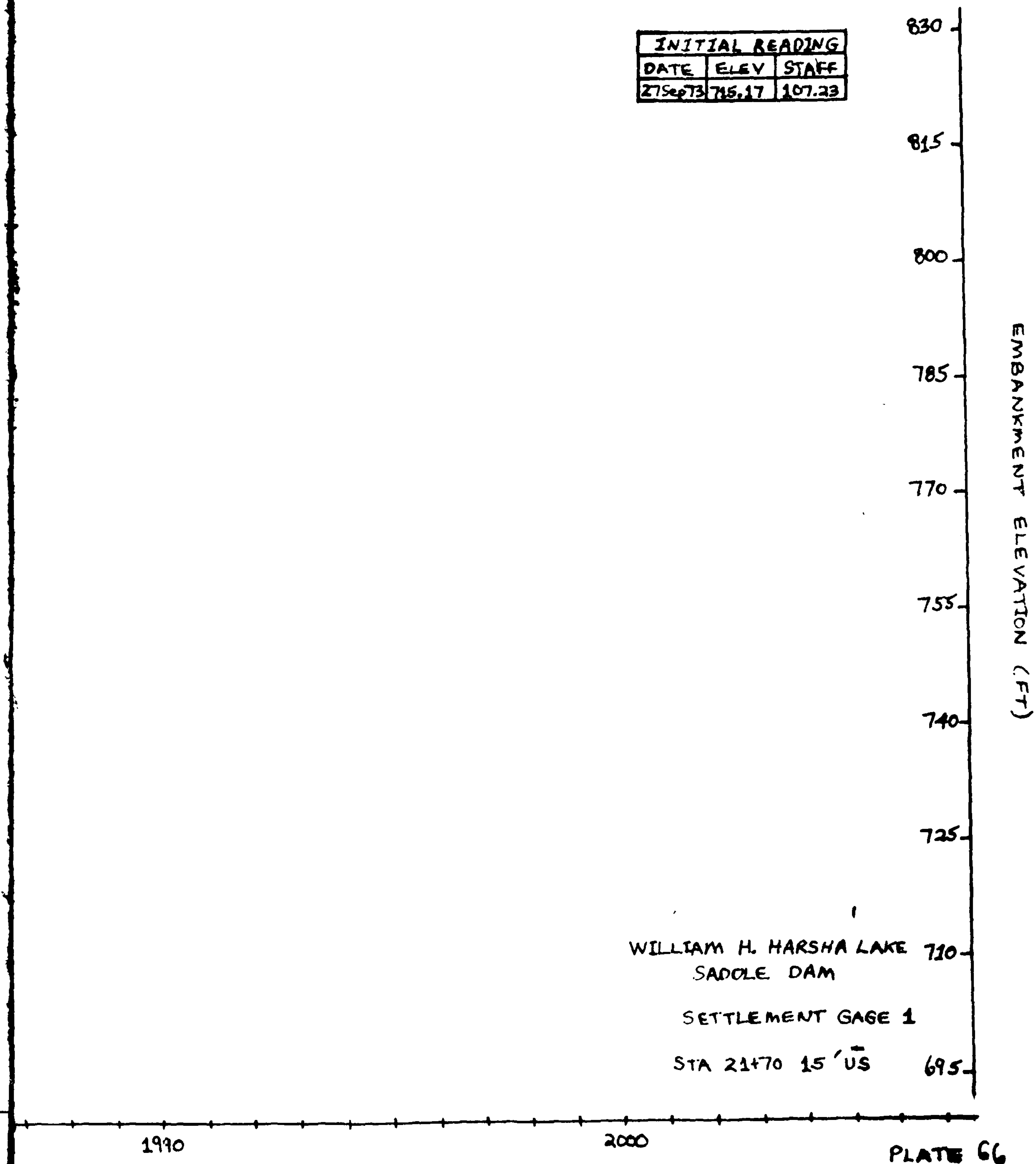
VERTICAL MOVEMENT

✱✱ MONUMENT RESET 1981

PLATE 65



715.0
714.0
713.0
PLATE ELEVATION (FT)
PLATE ELEVATION
SADDLE DAM EMBANKMENT
1970
1980



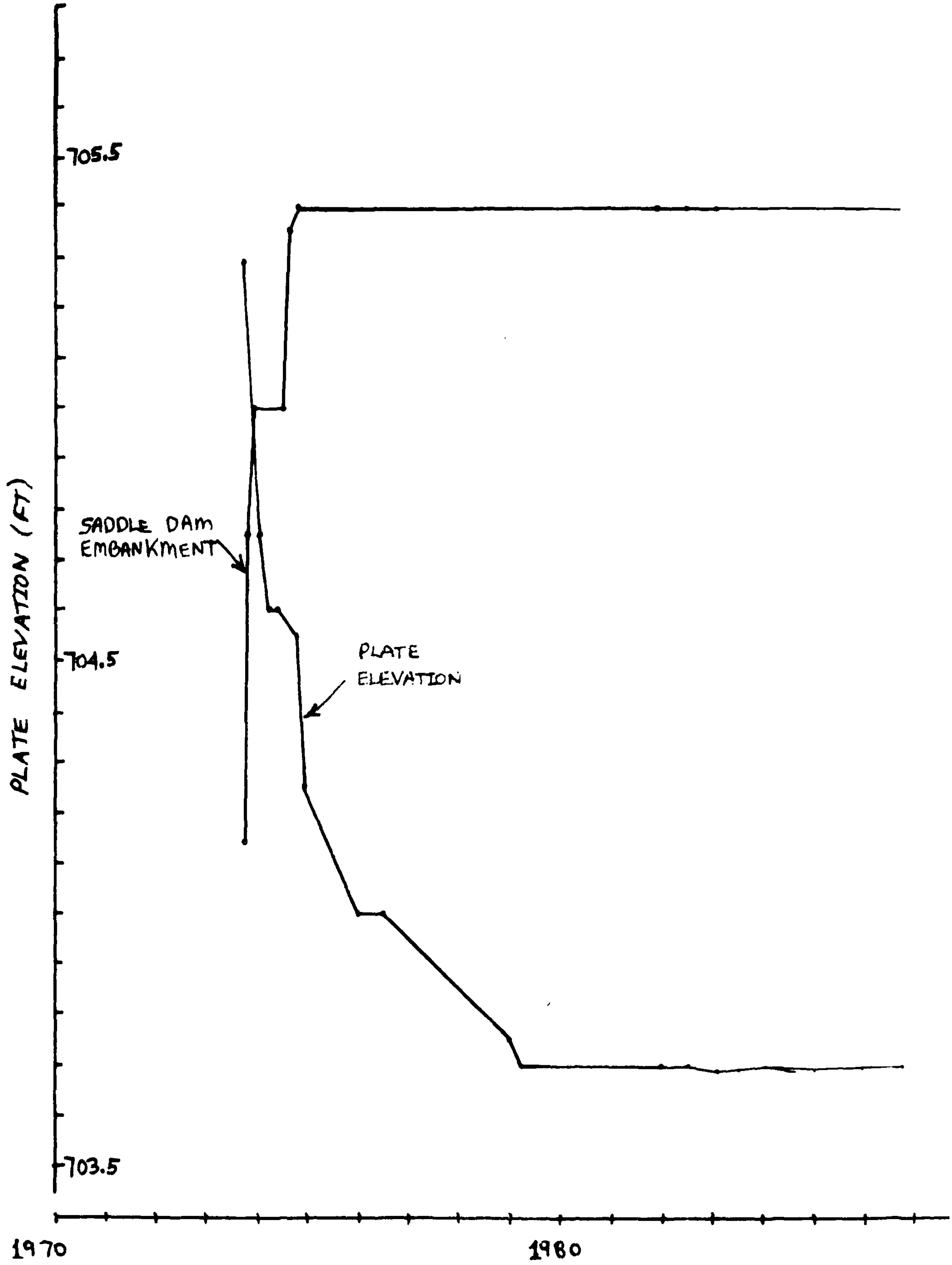
INITIAL READING		
DATE	ELEV	STAFF
27Sep73	715.17	107.23

WILLIAM H. HARSHA LAKE
SADDLE DAM

SETTLEMENT GAGE 1

STA 21+70 15' US

PLATE 66



705.5
704.5
703.5
PLATE ELEVATION (FT)
SADDLE DAM
EMBANKMENT
PLATE
ELEVATION
1970
1980

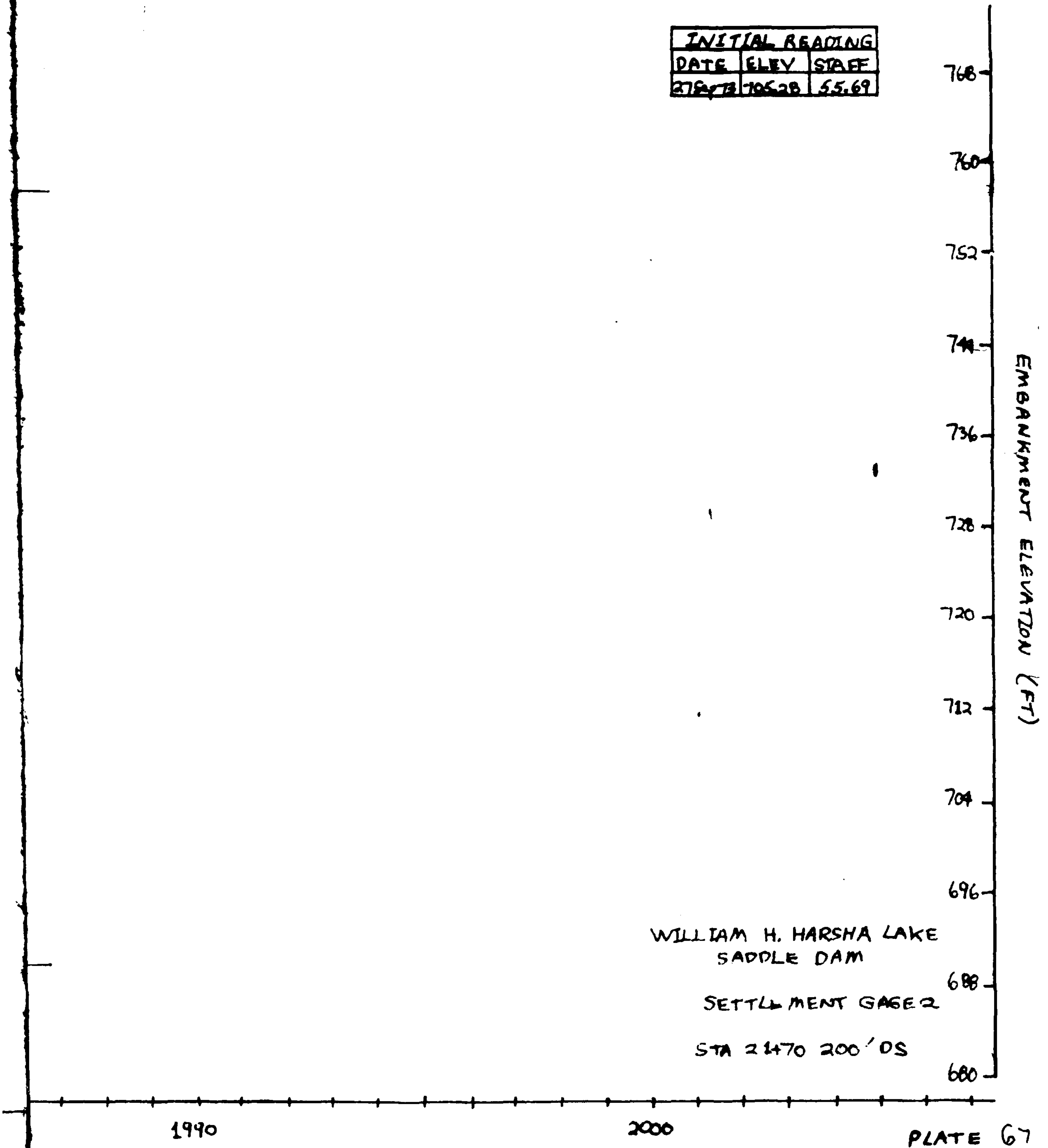

INITIAL READING
DATE | ELEV | STAFF
27Sep73 | 705.28 | 55.69
768
760
752
744
736
728
720
712
704
696
688
680
EMBANKMENT ELEVATION (FT)
1990
2000
WILLIAM H. HARSHA LAKE
SADDLE DAM
SETTLEMENT GAGE 2
STA 21+70 200' DS

PLATE 67

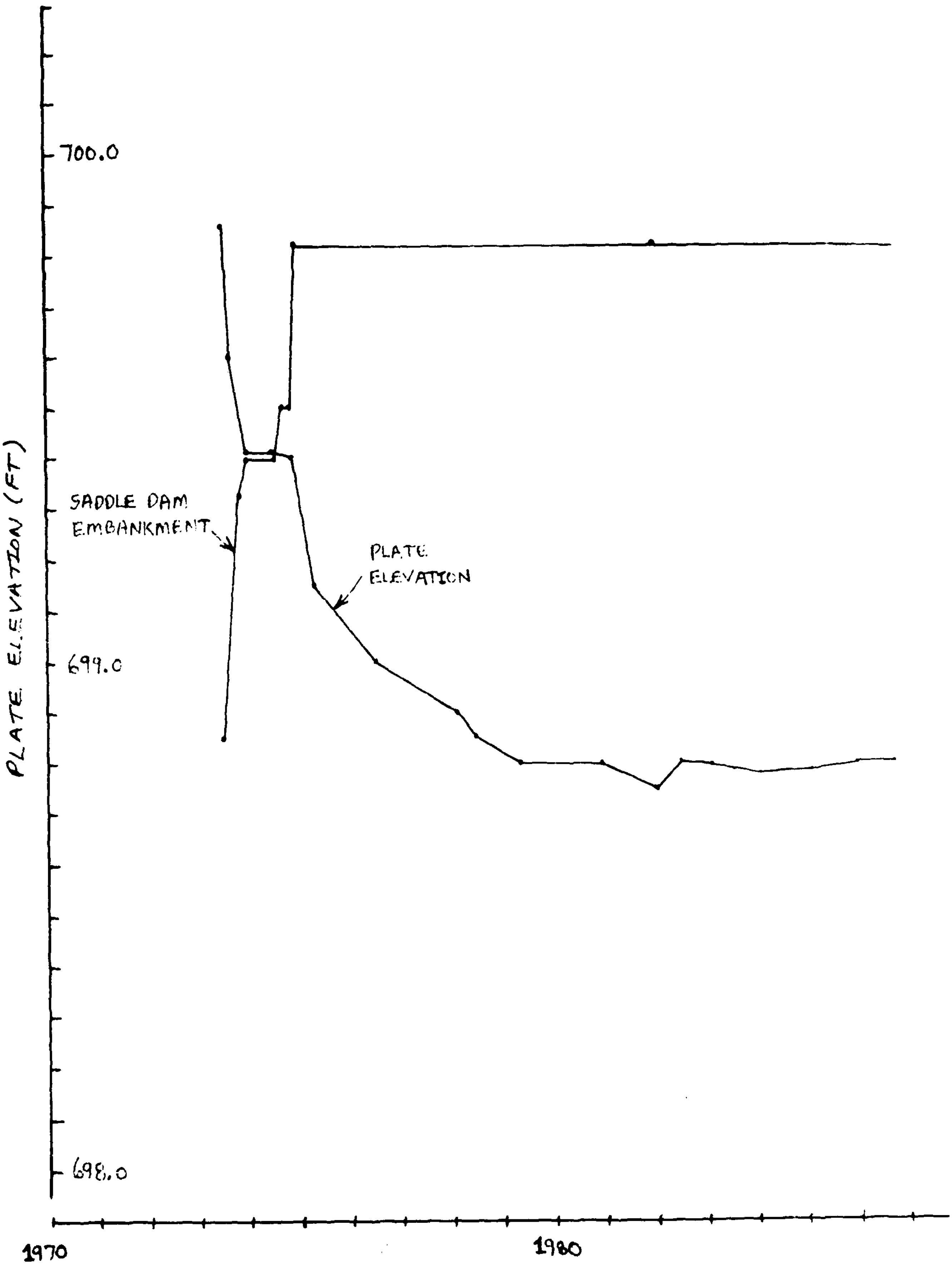
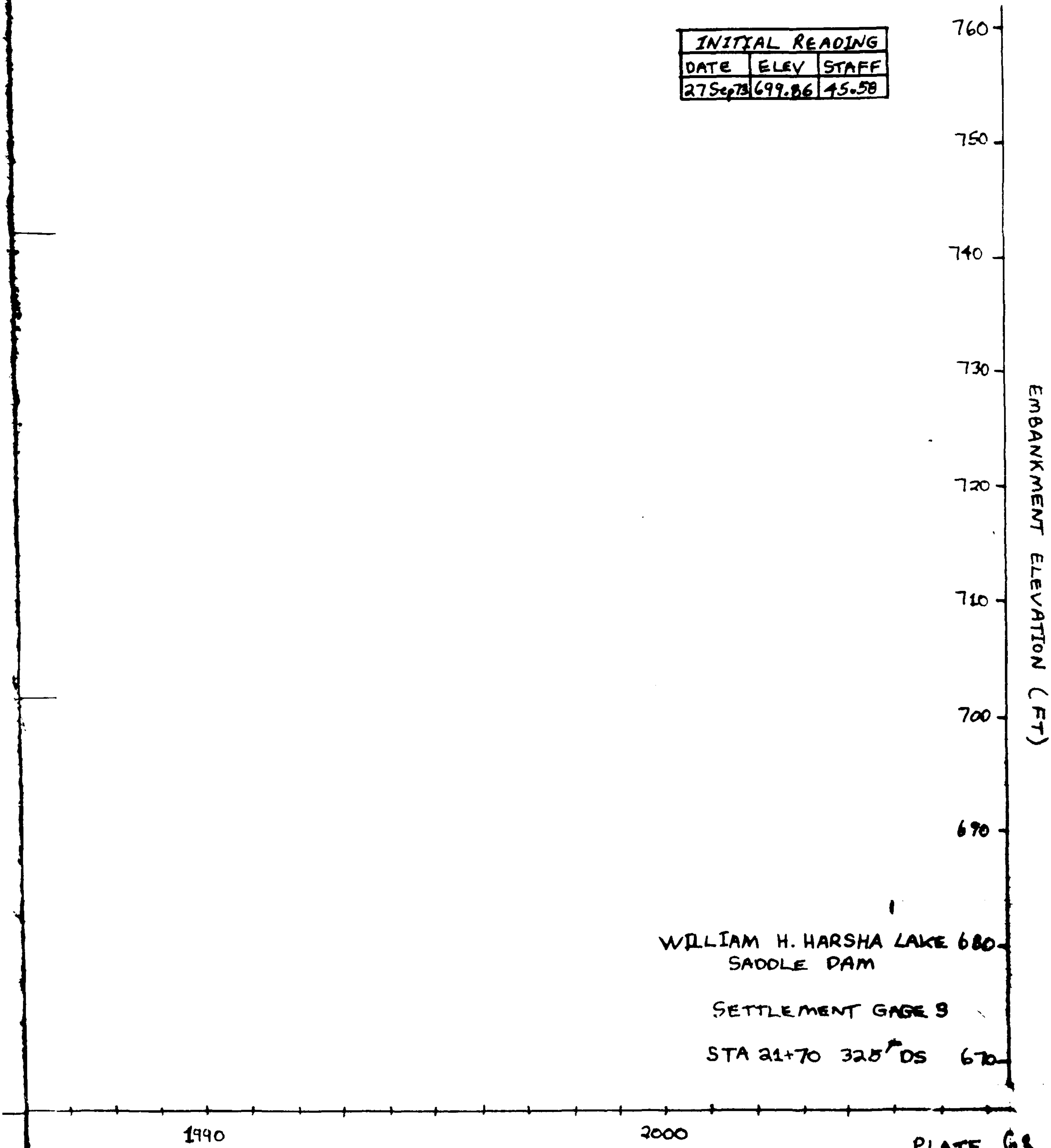


PLATE ELEVATION (FT)
700.0
699.0
698.0
SADDLE DAM
EMBANKMENT
PLATE
ELEVATION
1970
1980



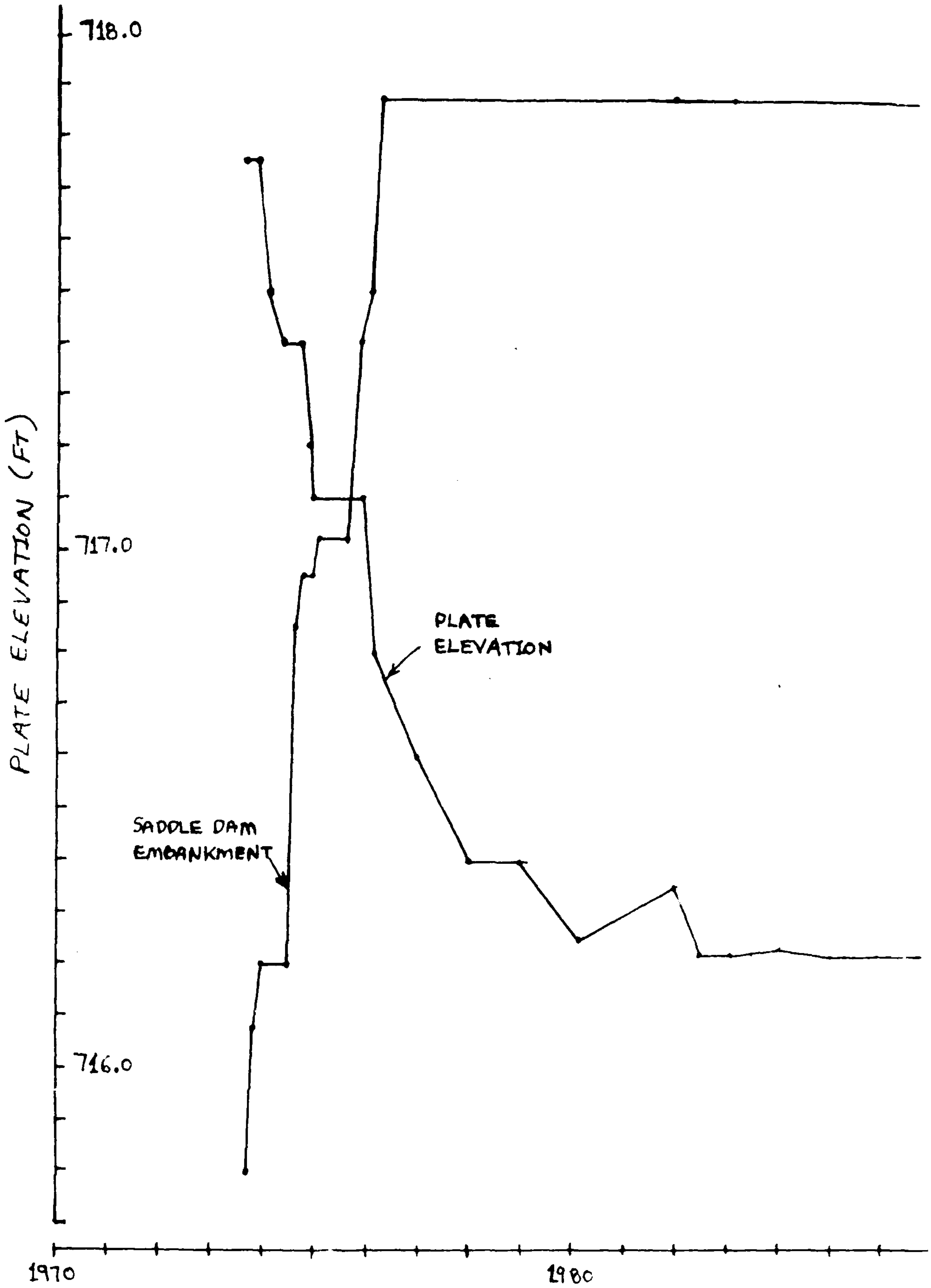
INITIAL READING		
DATE	ELEV	STAFF
27Sep73	699.86	45.58

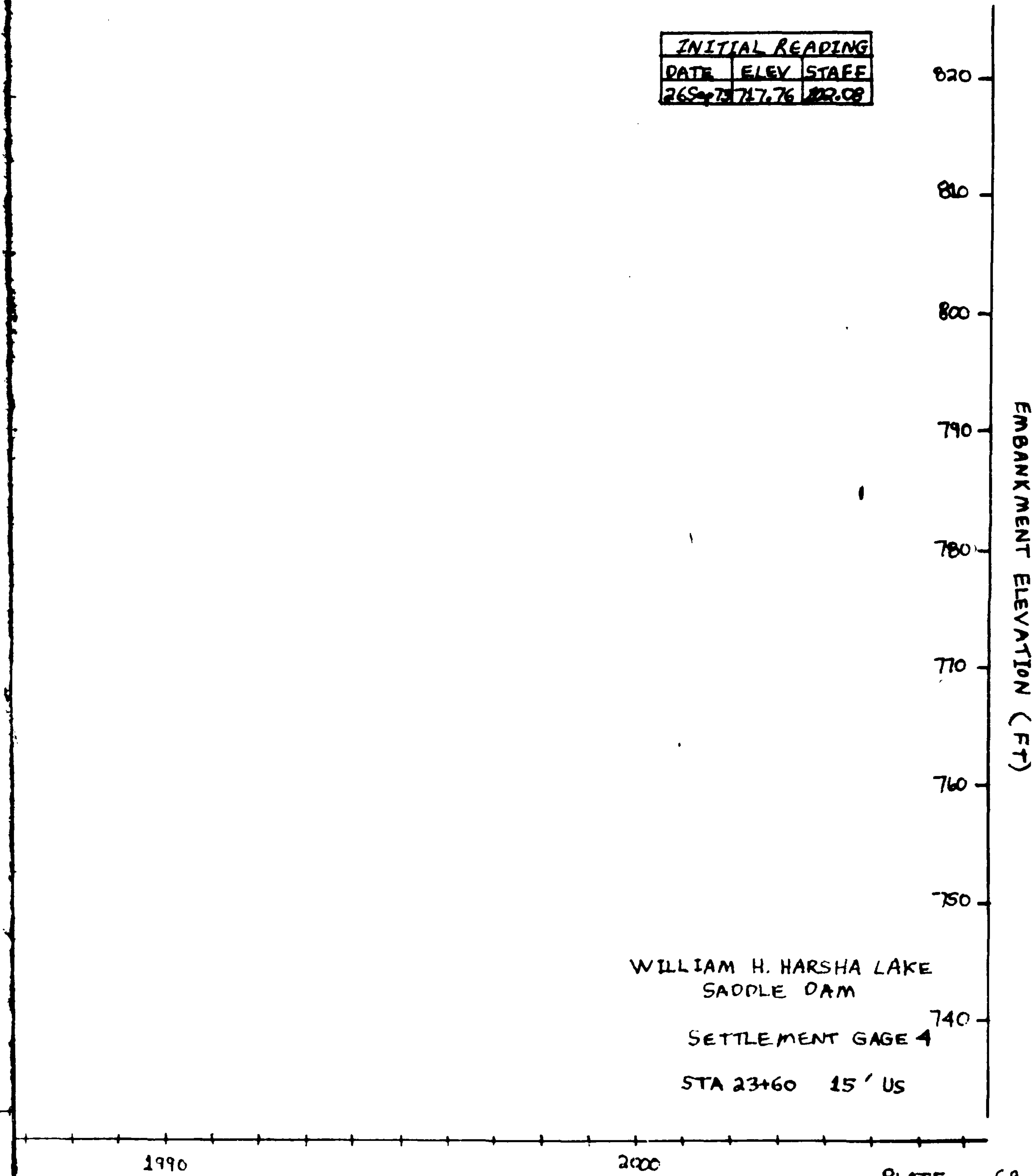
WILLIAM H. HARSHA LAKE
SADDLE DAM

SETTLEMENT GAGE 3

STA 21+70 325' DS

PLATE 68

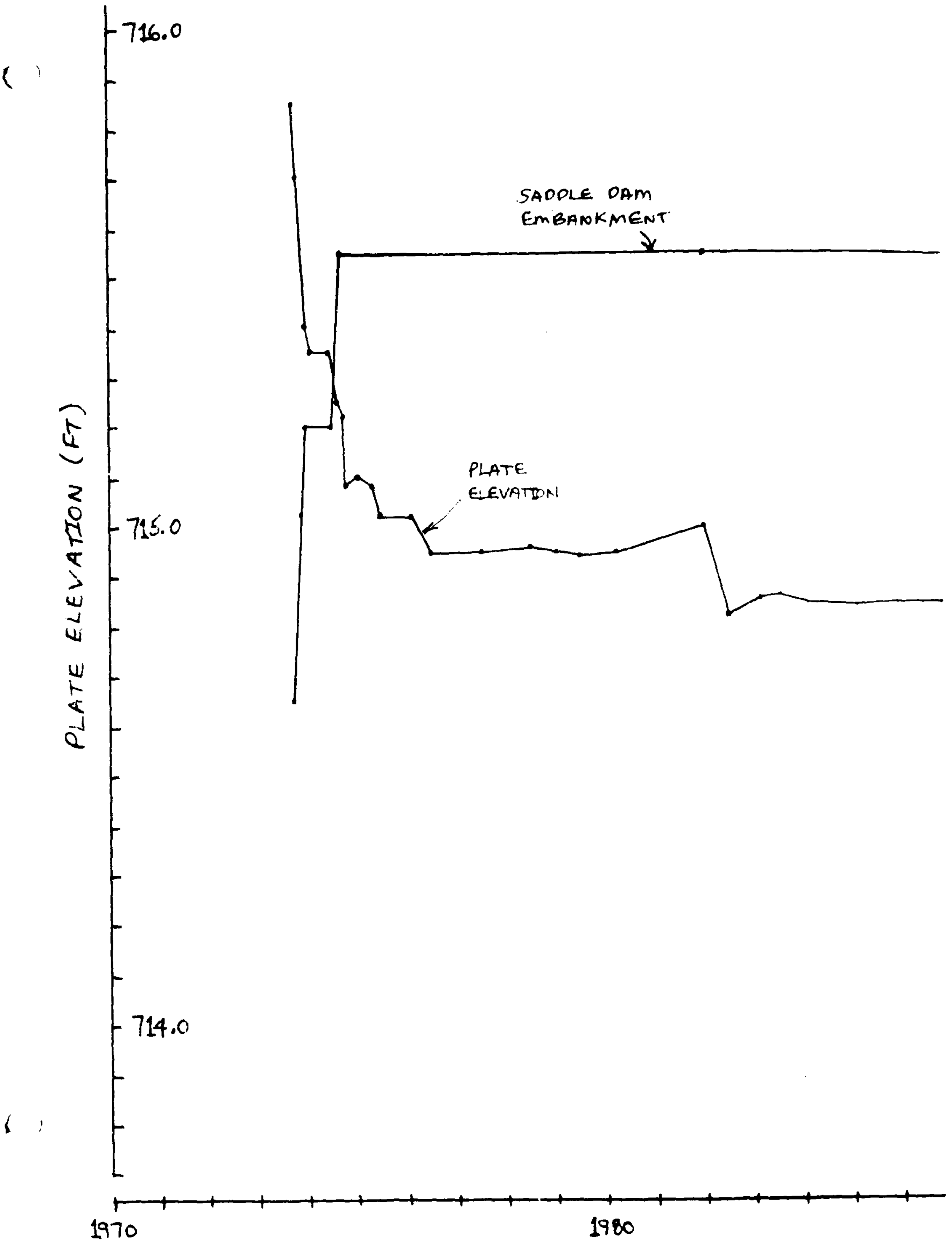

718.0
717.0
716.0
PLATE ELEVATION (FT)
PLATE
ELEVATION
SADDLE DAM
EMBANKMENT
1970
1980



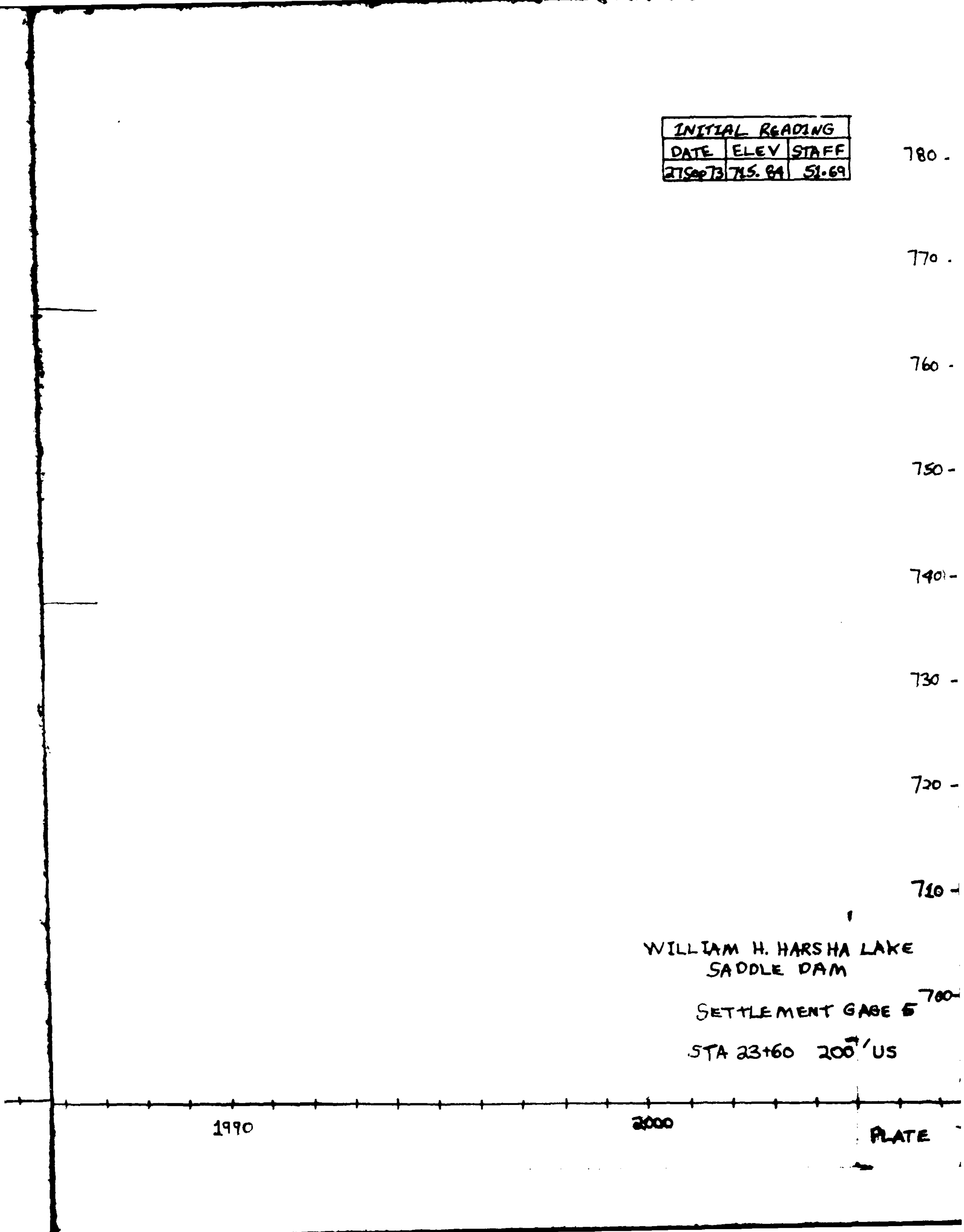
INITIAL READING		
DATE	ELEV	STAFF
26Sep75	717.76	102.08

820
810
800
790
780
770
760
750
740
EMBANKMENT ELEVATION (FT)
1990
2000
WILLIAM H. HARSHA LAKE
SADDLE DAM
SETTLEMENT GAGE 4
STA 23+60 15' US

PLATE 69



716.0
715.0
714.0
PLATE ELEVATION (FT)
SADDLE DAM EMBANKMENT
PLATE ELEVATION
1970
1980



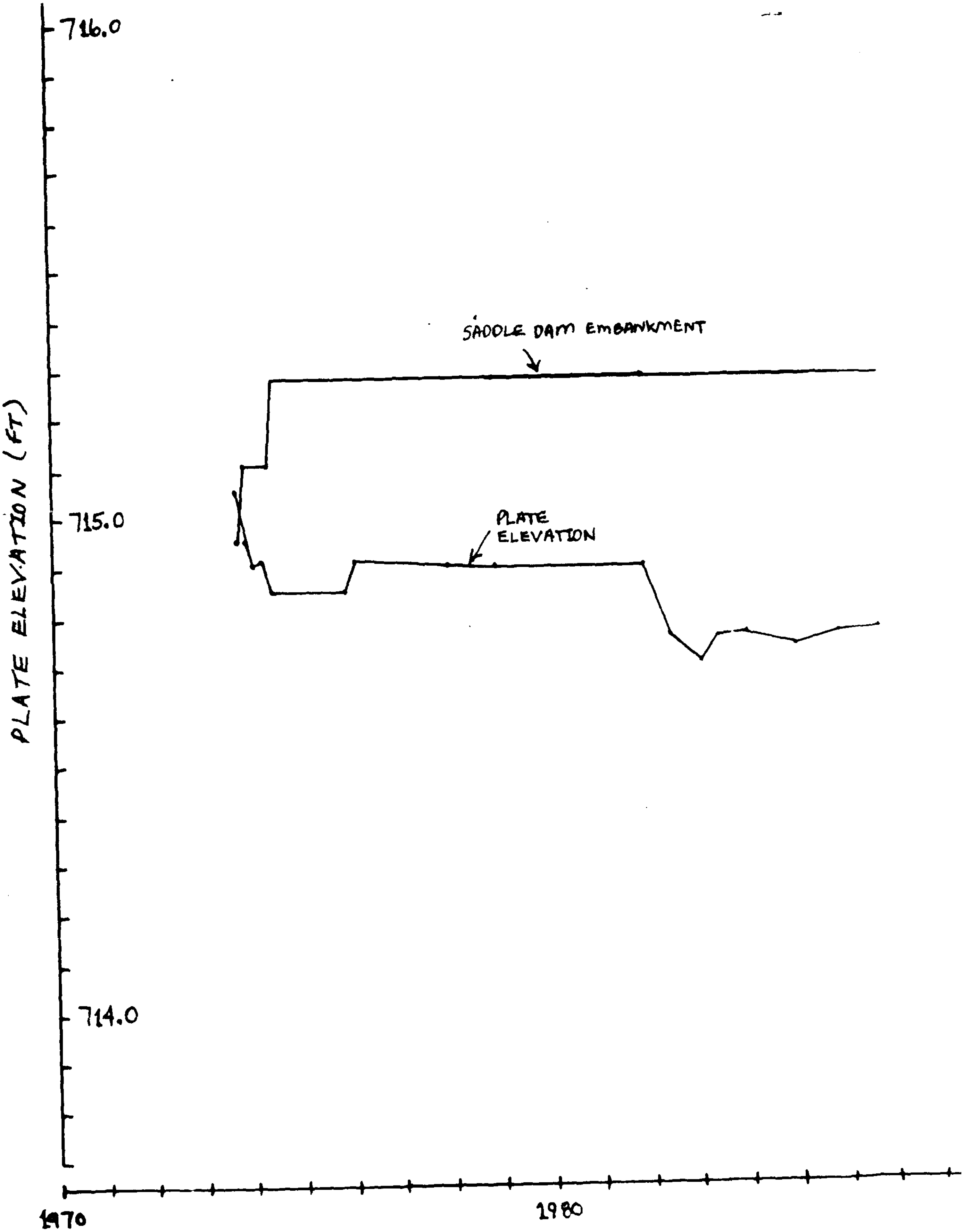
INITIAL READING		
DATE	ELEV	STAFF
27Sep73	715.84	51.69

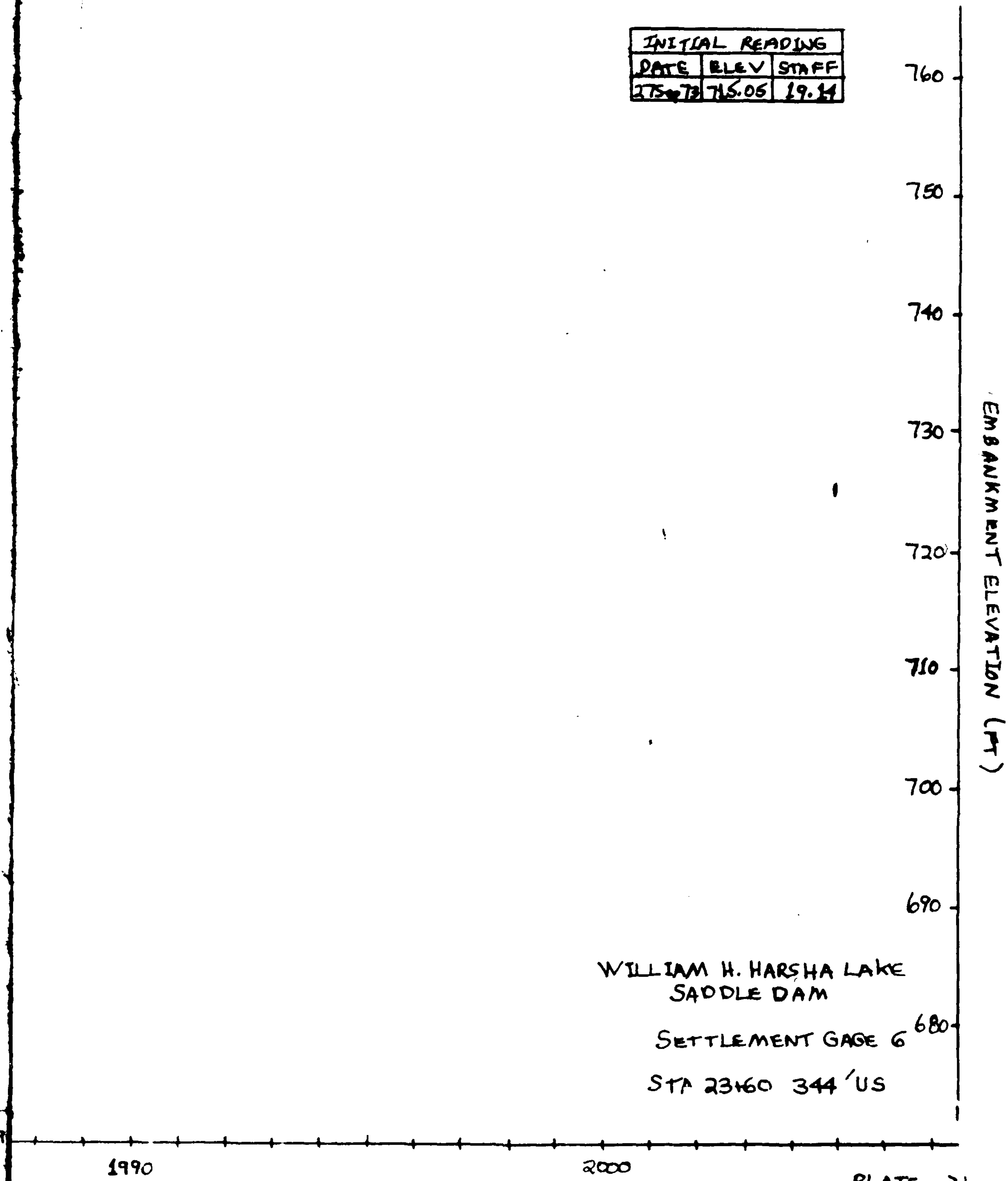
WILLIAM H. HARSHA LAKE
SADDLE DAM

SETTLEMENT GAGE 5

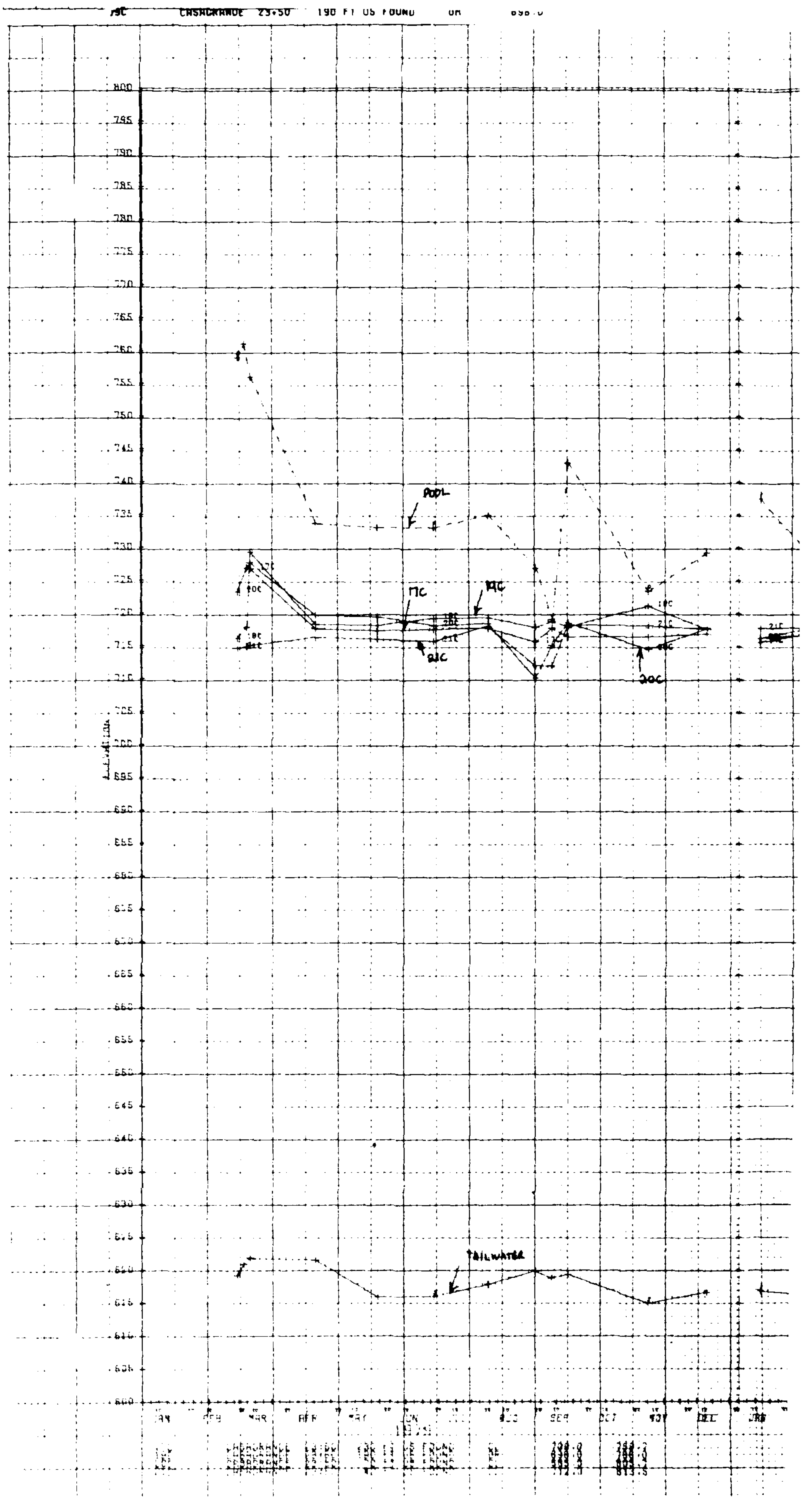
STA 23+60 200'US

PLATE

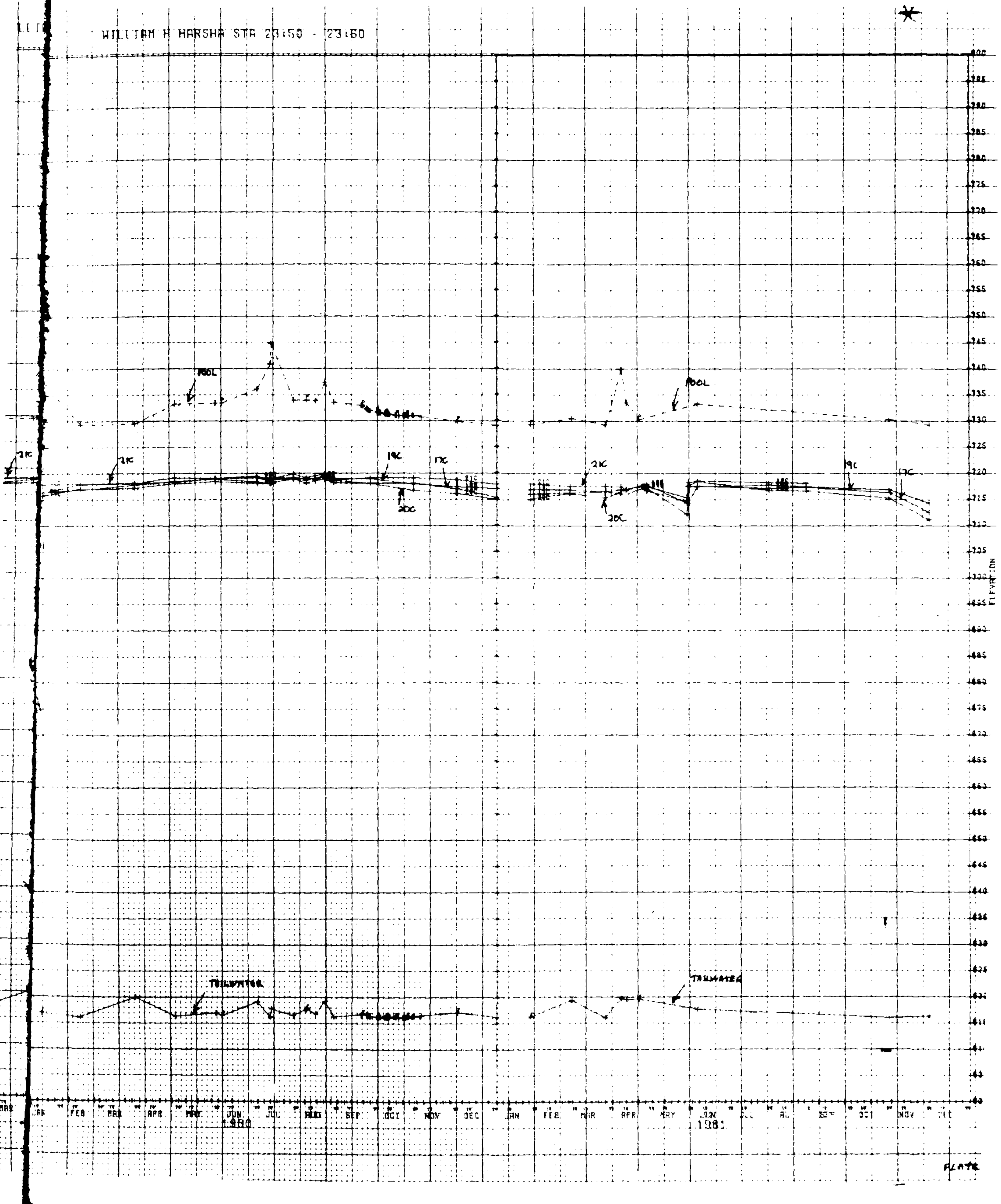

716.0
715.0
714.0
PLATE ELEVATION (FT)
SADDLE DAM EMBANKMENT
PLATE
ELEVATION
1970
1980

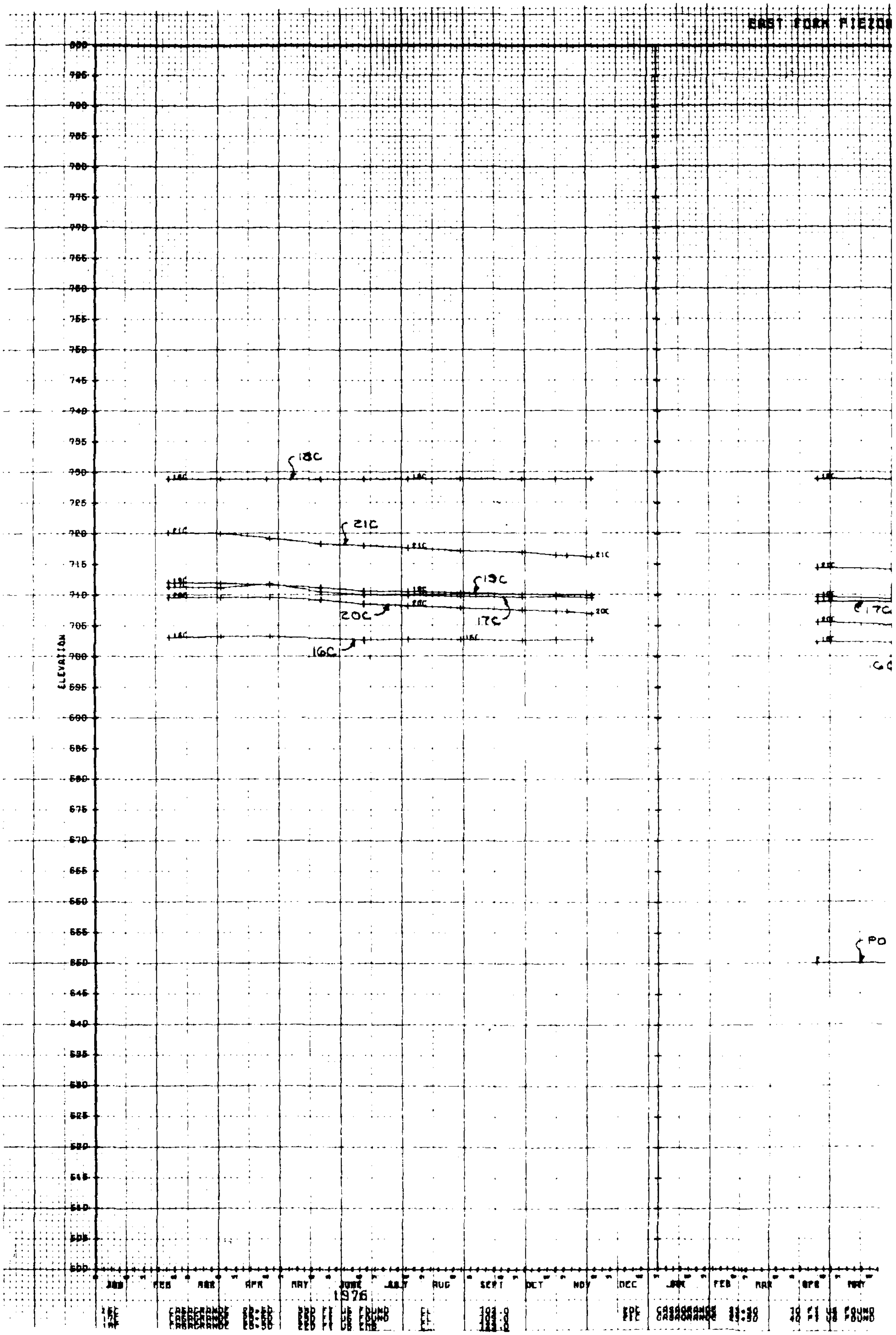


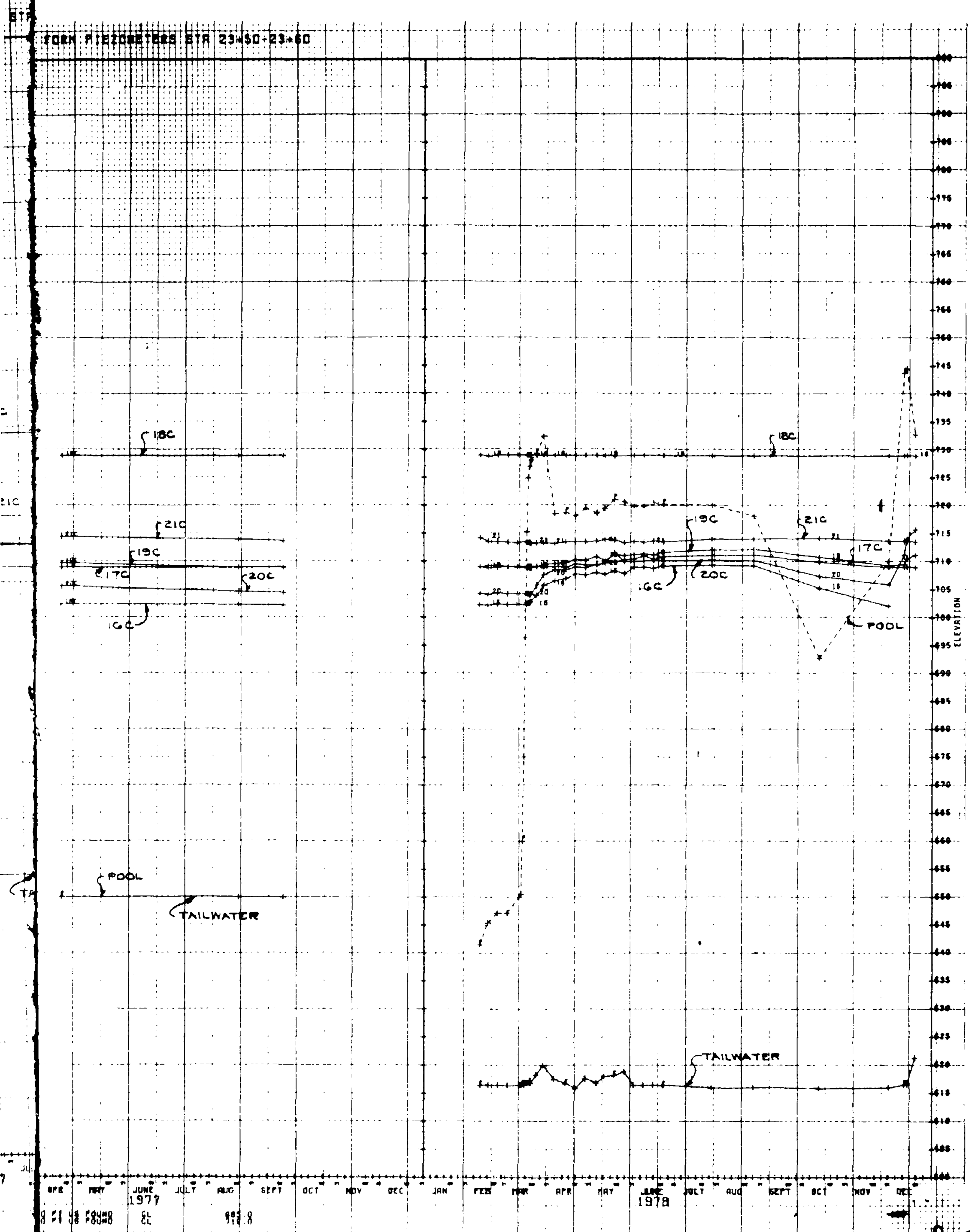
INITIAL READING		
DATE	ELEV	STAFF
27S[illegible]73	715.06	19.14



CASAGRANDE 23+50 190 FT US FOUND
POOL
17C
19C
21C
20C
TAILWATER

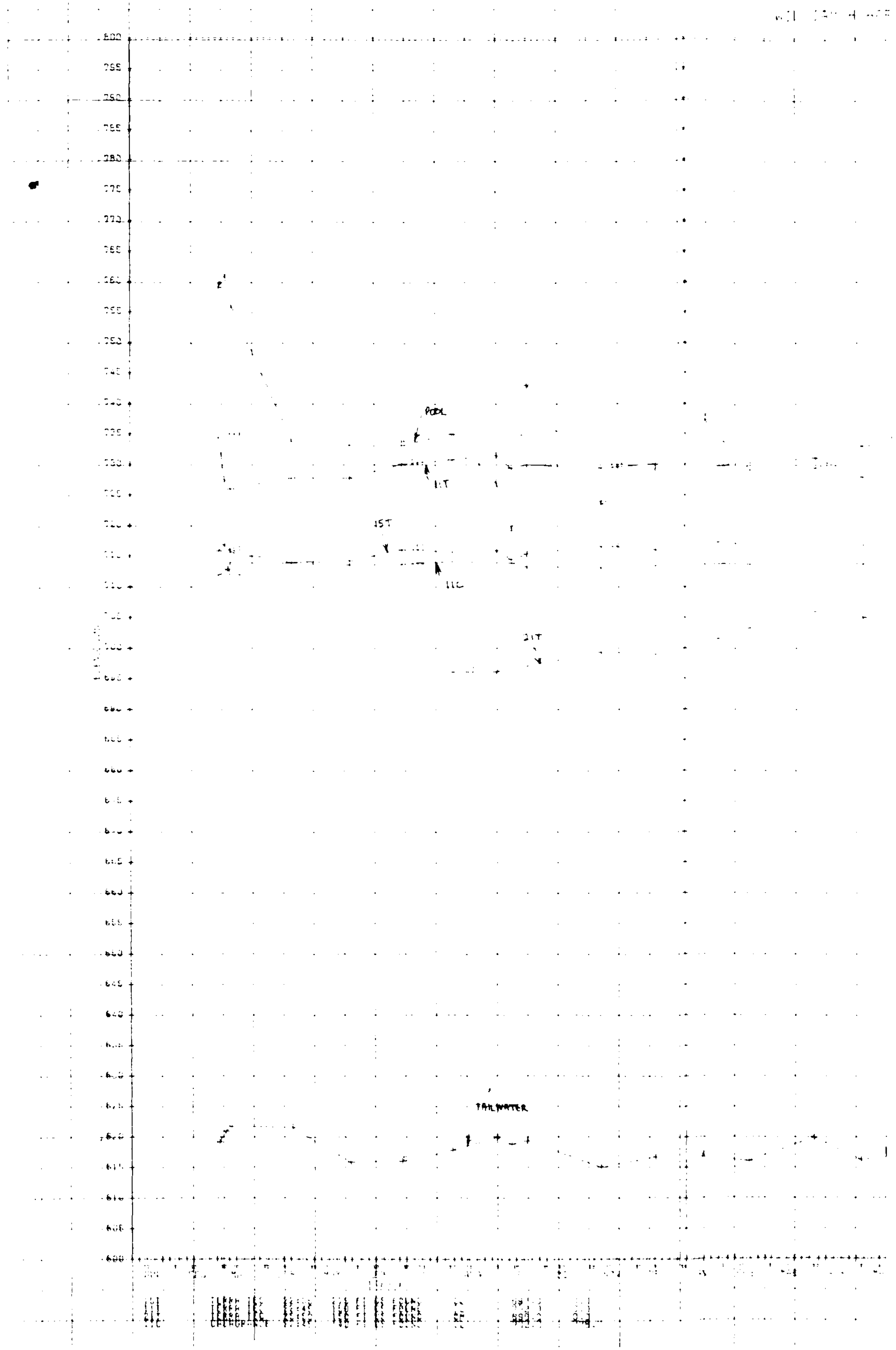

WILLIAM H HARSHA STA 23:50 - 23:50
POOL
21C
19C
17C
20C
TAILWATER
ELEVATION
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
1980
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
1981
PLATE


EAST FORK PIEZO
ELEVATION
18C
21C
19C
20C
17C
16C
17C
PO
FEB
APR
MAY
JUNE
AUG
SEPT
OCT
NOV
DEC
FEB
MAY
1976



FORM PIEZOMETERS STA 23+50-23+60
18C
21C
19C
17C
20C
16C
POOL
TAILWATER
ELEVATION
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
MAR
1977
1978

PLATE 73


POOL
TAILWATER

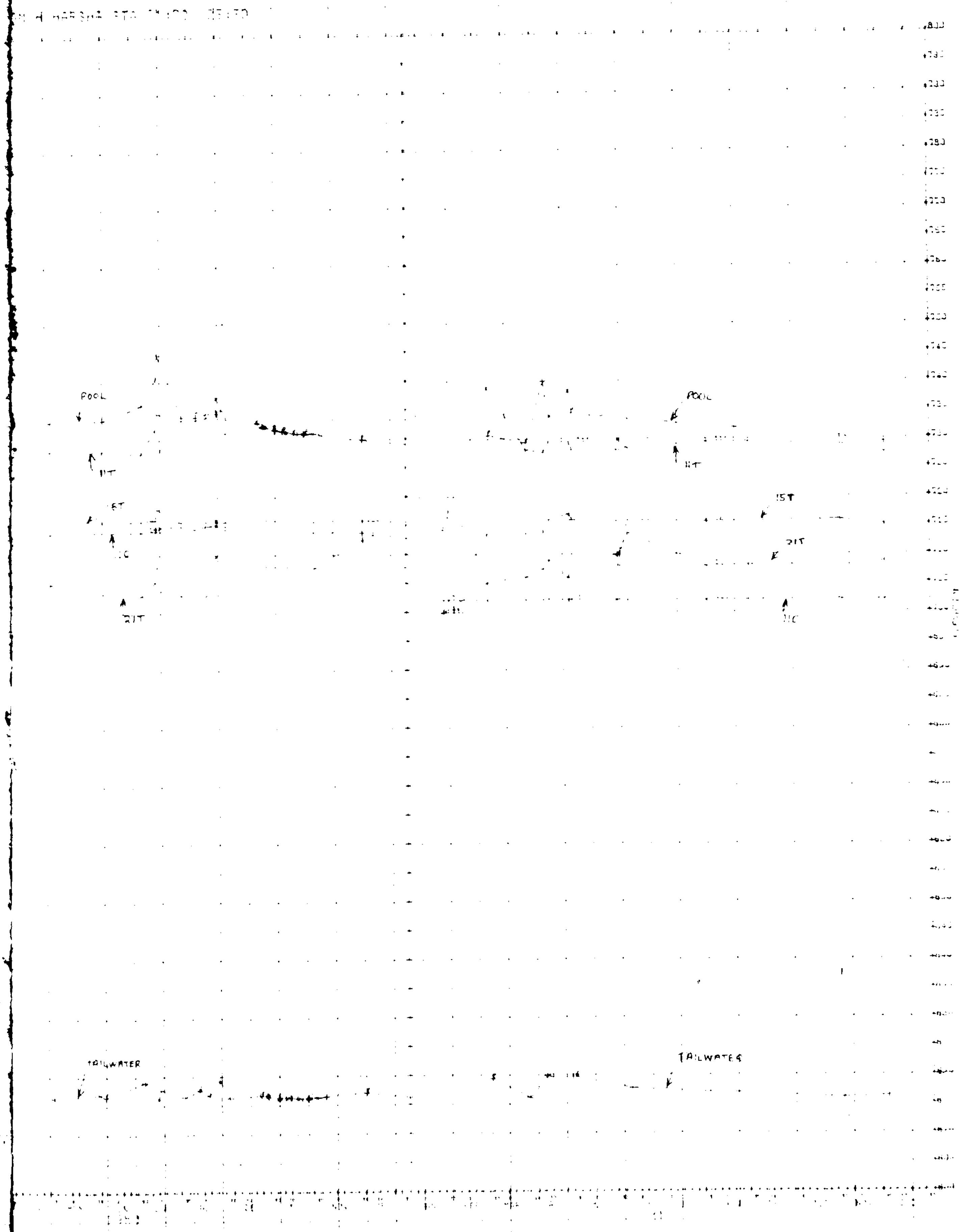
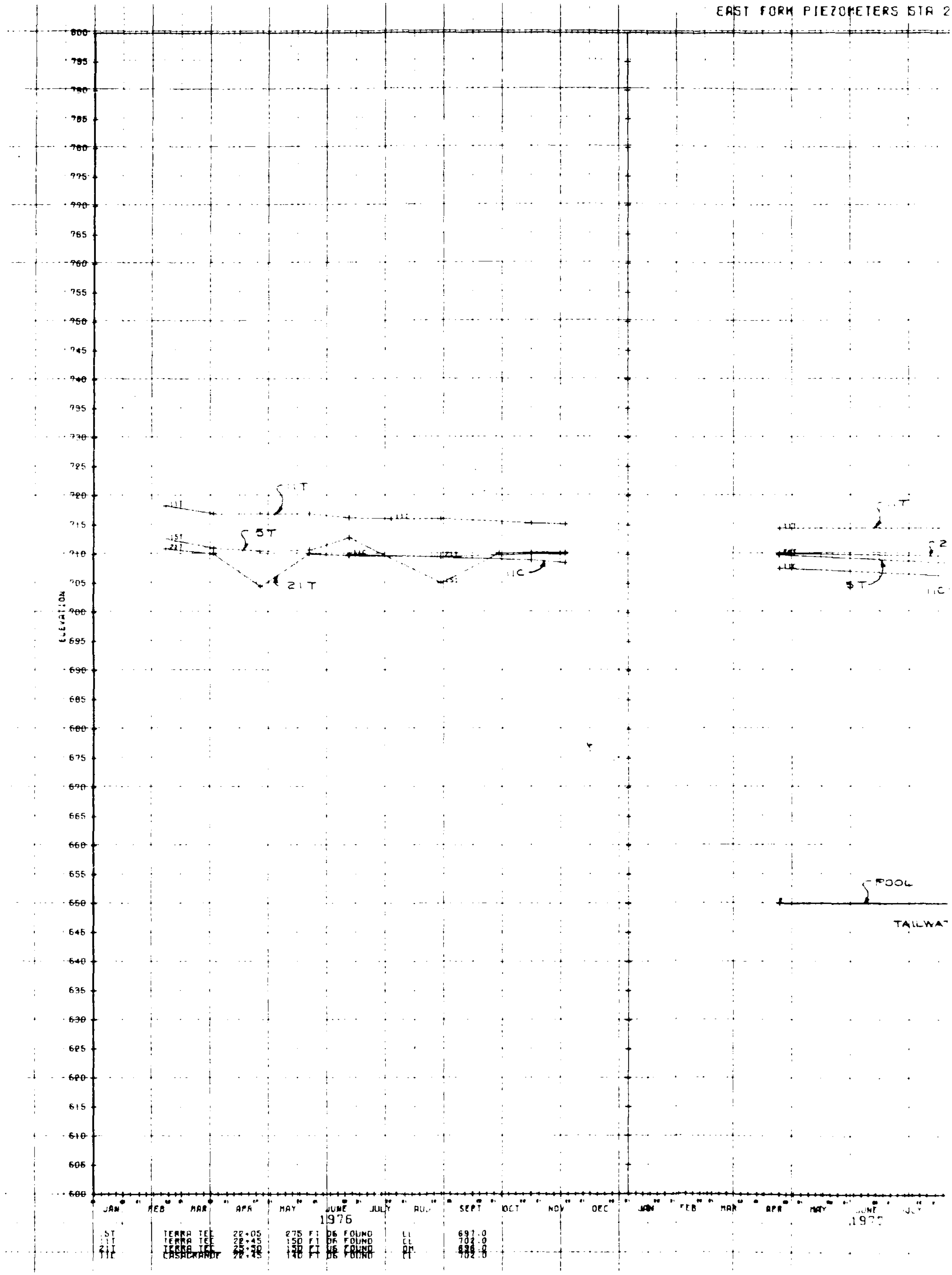
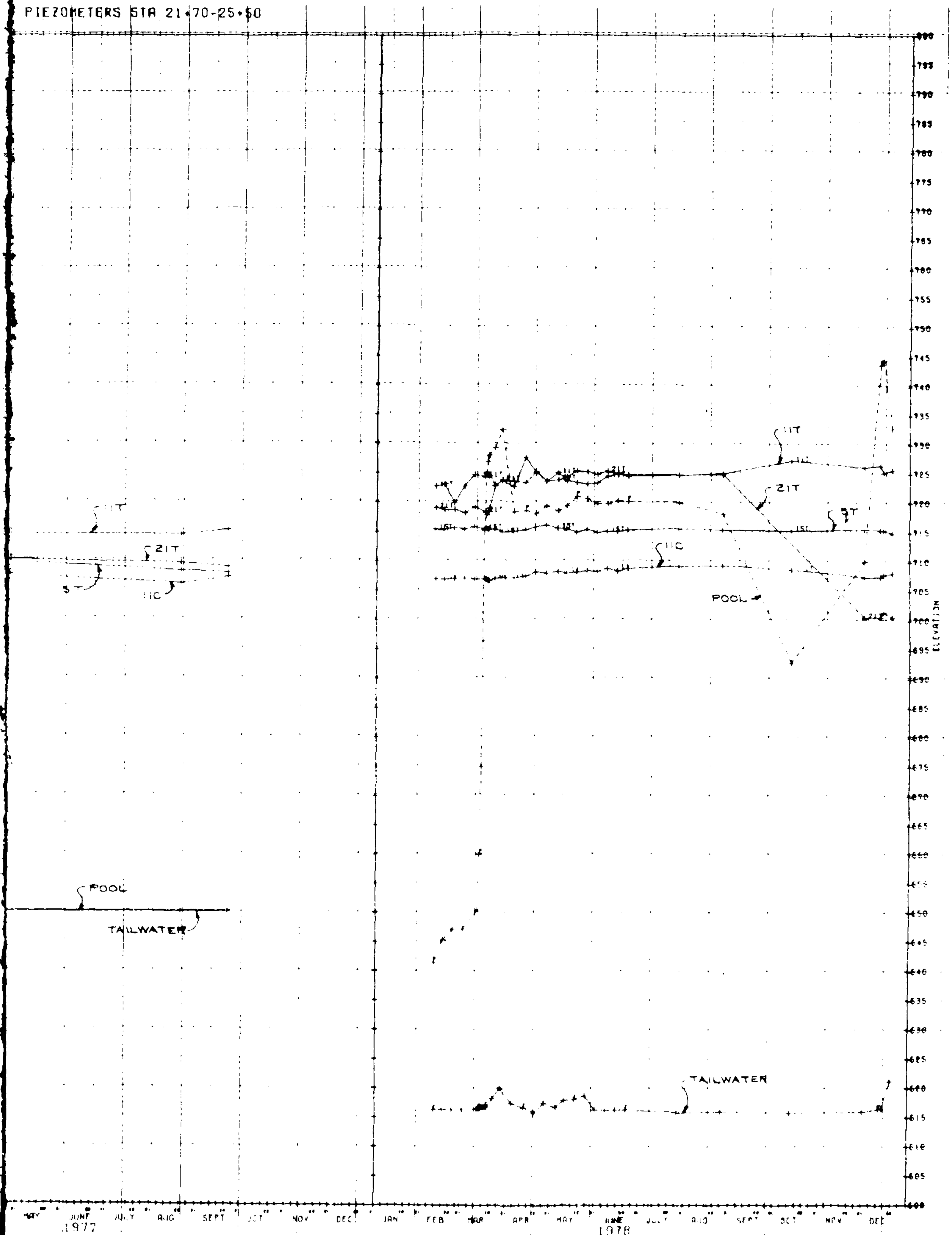


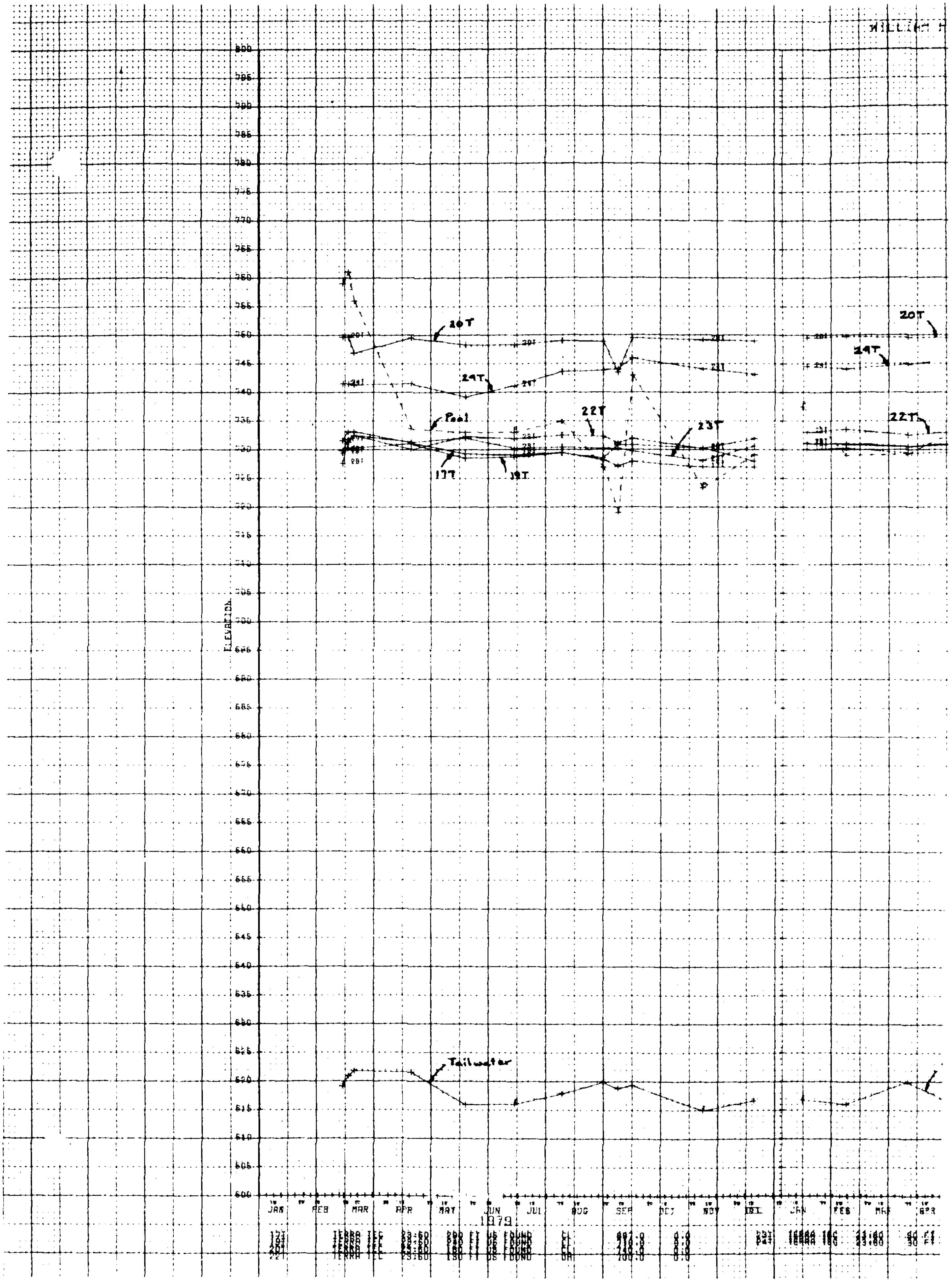
PLATE 94


EAST FORK PIEZOMETERS STA 2
ELEVATION
800
795
790
785
780
775
770
765
760
755
750
745
740
735
730
725
720
715
710
705
700
695
690
685
680
675
670
665
660
655
650
645
640
635
630
625
620
615
610
605
600
11T
5T
21T
11C
POOL
TAILWA
JAN
FEB
MAR
APR
MAY
JUNE
JULY
SEPT
OCT
NOV
DEC
1976
5T TERRA TEC 22+05 275 FT DS FOUND LL 697.0
11T TERRA TEC 22+45 150 FT DS FOUND CL 702.0
21T TERRA TEC 25+50 150 FT US FOUND DM 696.0
11C CASAGRANDE 22+45 140 FT DS FOUND LL 702.0



PIEZOMETERS STA 21+70-25+50
11T
21T
5T
11C
POOL
TAILWATER
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
MAR
APR
JULY
SEPT
1977
1978
ELEVATION
800
795
790
785
780
775
770
765
760
755
750
745
740
735
730
725
720
715
710
705
700
695
690
685
680
675
670
665
660
655
650
645
640
635
630
625
620
615
610
605
600

PLATE 75



WILLIAM H
ELEVATION
800
795
790
785
780
775
770
765
760
755
750
745
740
735
730
725
720
715
710
705
700
695
690
685
680
675
670
665
660
655
650
645
640
635
630
625
620
615
610
605
600
20T
24T
Pool
22T
23T
17T
19T
Tailwater
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB
MAR
APR
1979
TERRA TEC
23:60
US FOUND

WILLIAM H HARSHA STH 23+60

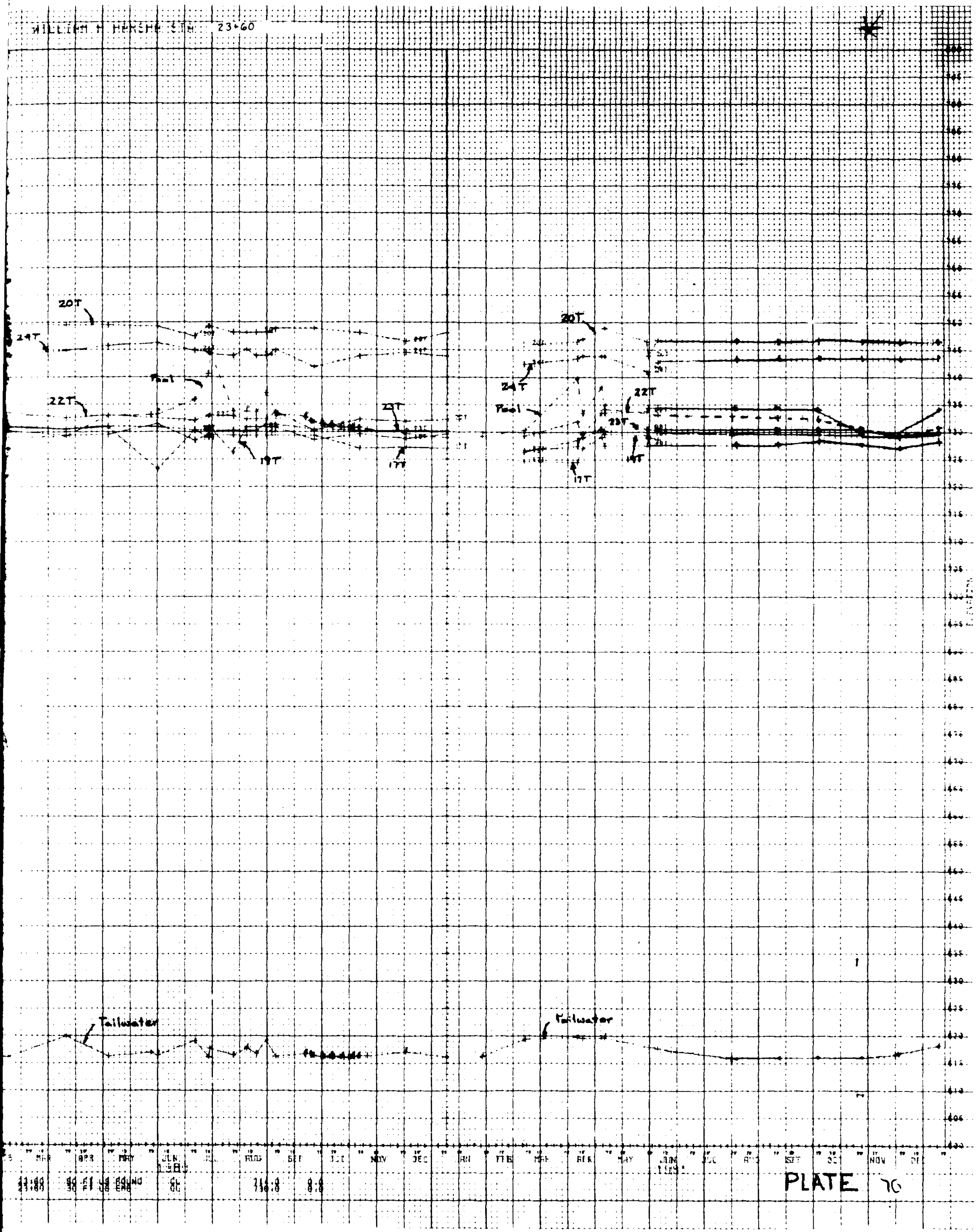
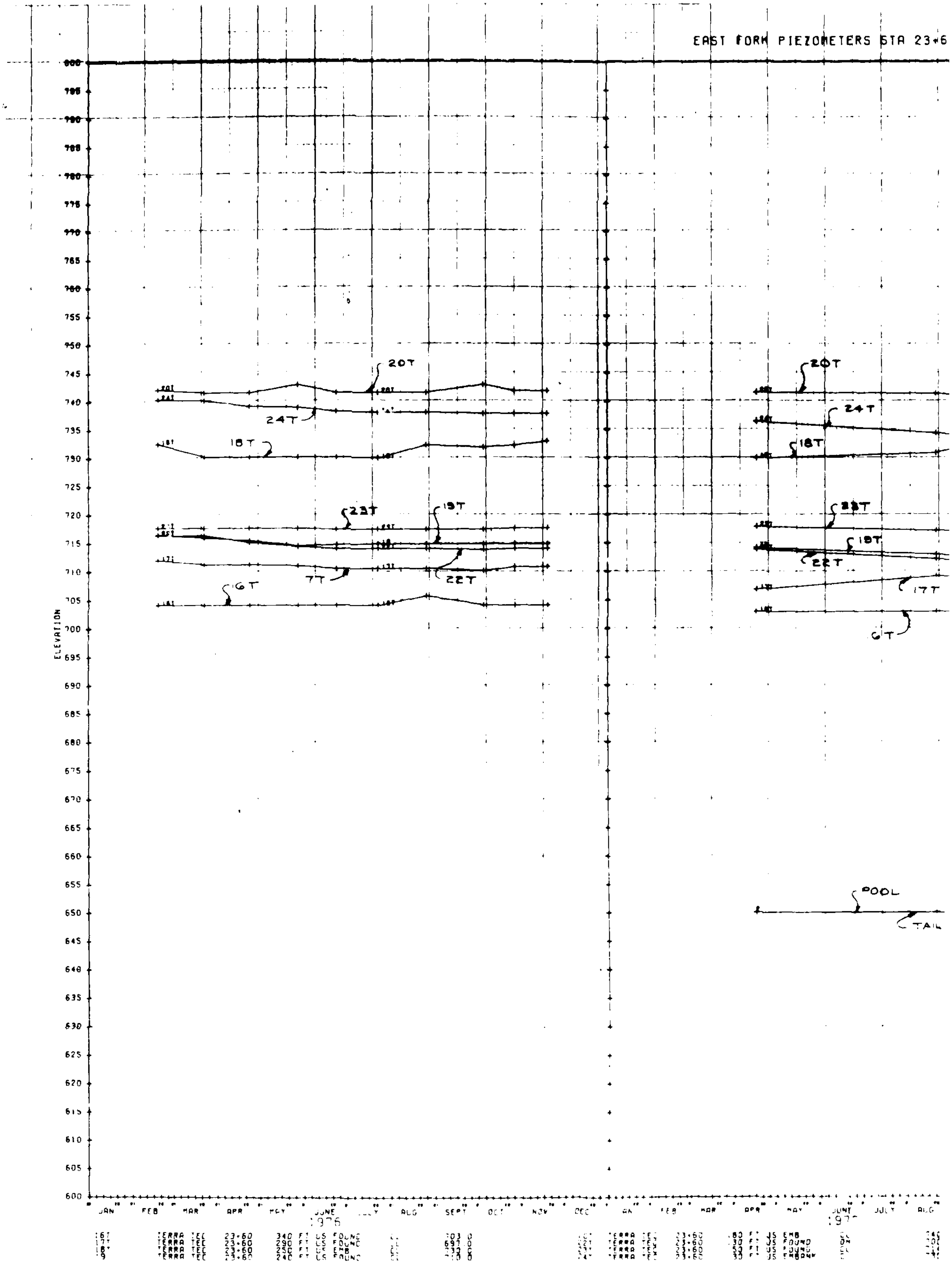


PLATE 76


EAST FORK PIEZOMETERS STA 23+6
ELEVATION
20T
24T
18T
23T
19T
22T
17T
16T
POOL
TAIL
JAN
FEB
MAR
APR
MAY
JUNE
1976
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUNE
JULY
AUG

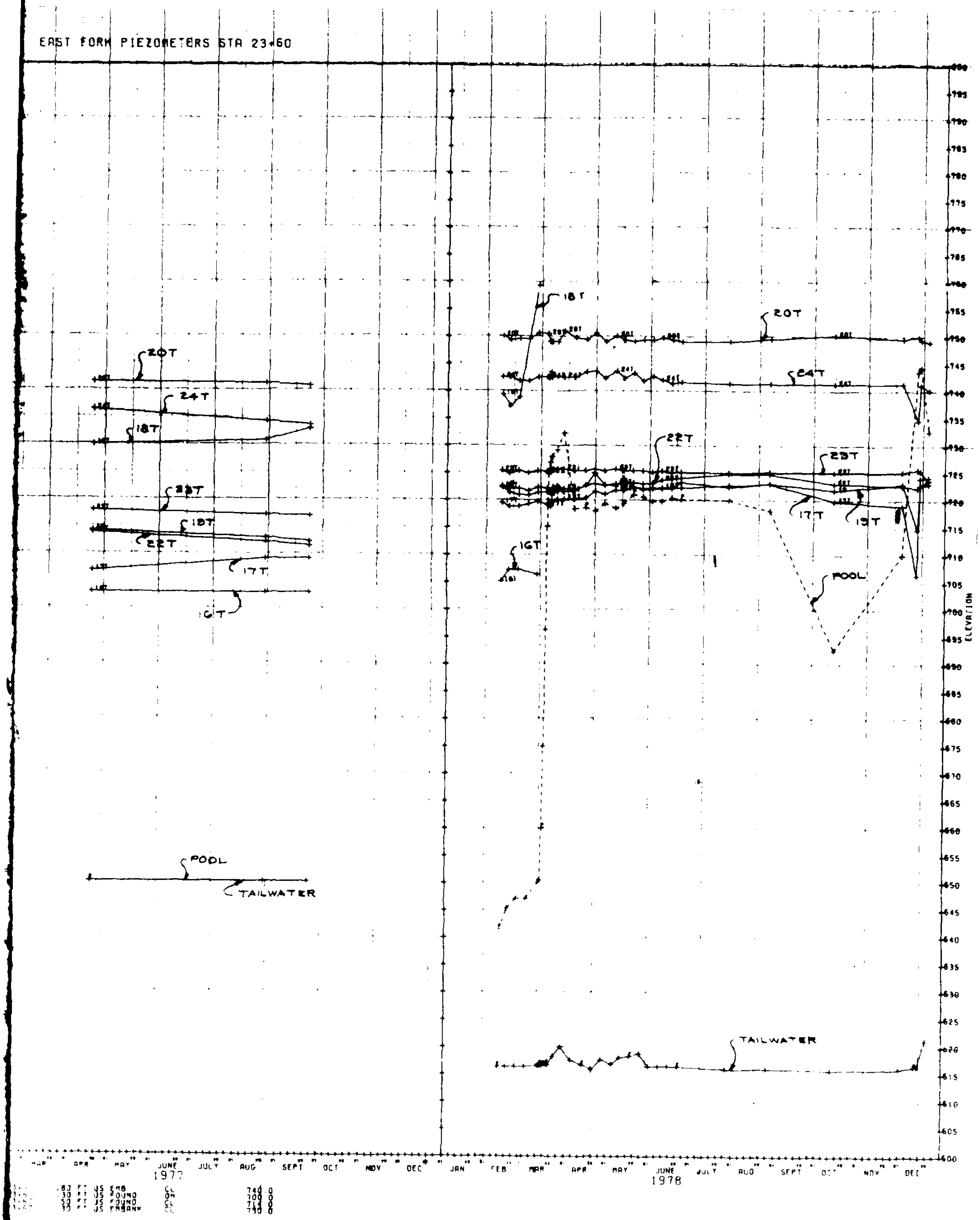
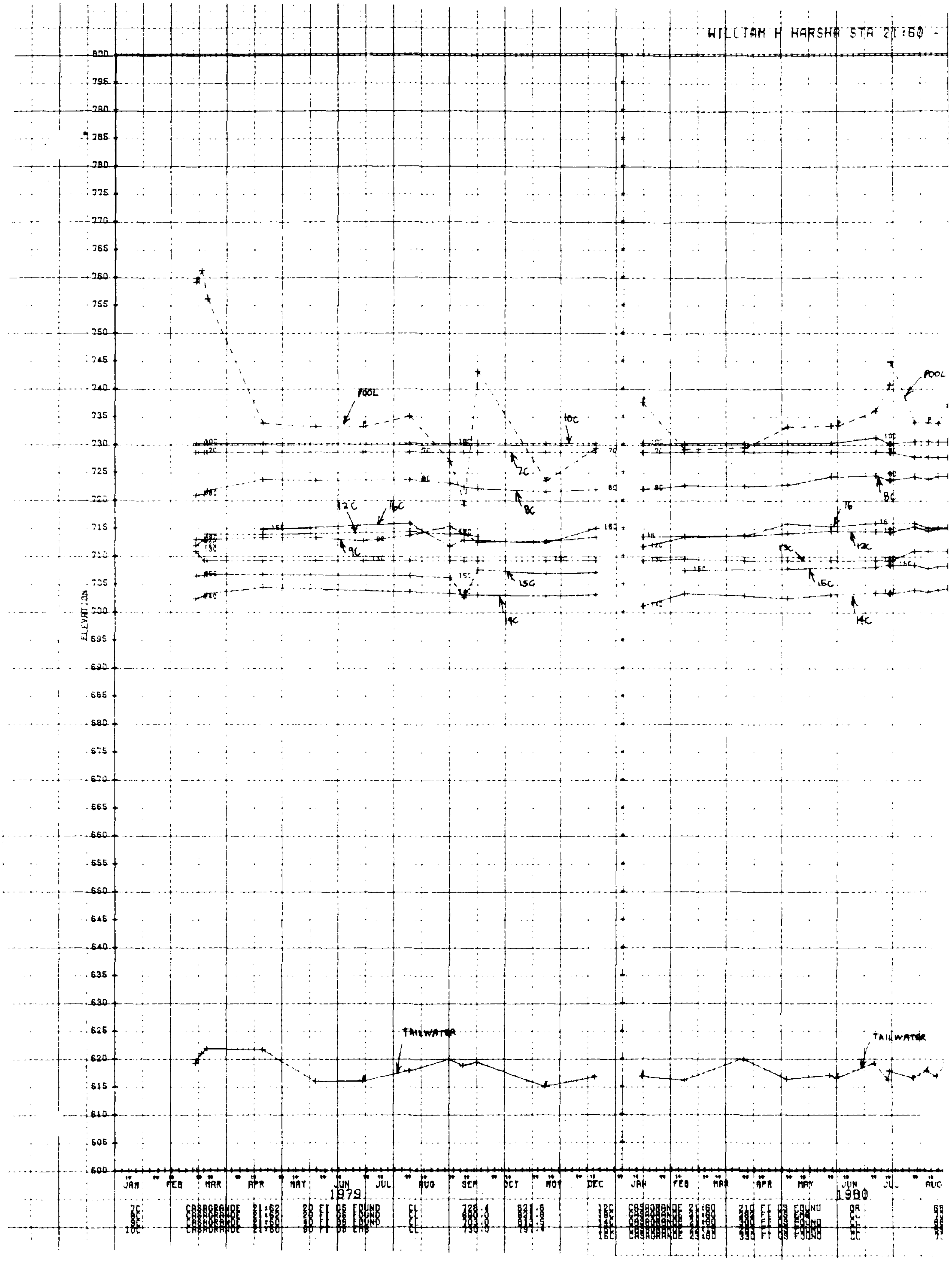

EAST FORK PIEZOMETERS STA 23+60
20T
24T
18T
23T
19T
22T
17T
16T
15T
POOL
TAILWATER
ELEVATION
MAR APR MAY JUNE JULY AUG SEPT OCT NOV DEC
1977
JAN FEB MAR APR MAY JUNE JULY AUG SEPT OCT NOV DEC
1978
30 FT US FOUND OM 700.0
50 FT US FOUND CL 715.0
30 FT US EMBANK CL 730.0

PLATE 77



WILLIAM H HARSHA STA 21:60 -
ELEVATION
800
795
790
785
780
775
770
765
760
755
750
745
740
735
730
725
720
715
710
705
700
695
690
685
680
675
670
665
660
655
650
645
640
635
630
625
620
615
610
605
600
POOL
TAILWATER
7C
8C
9C
10C
12C
13C
14C
15C
16C
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
1979
JAN FEB MAR APR MAY JUN JUL AUG
1980
CASAGRANDE 21:62 20 FT OS FOUND CL
CASAGRANDE 21:60 80 FT OS EMB CL
CASAGRANDE 21:60 210 FT OS FOUND OR
CASAGRANDE 23:60 330 FT OS FOUND CL

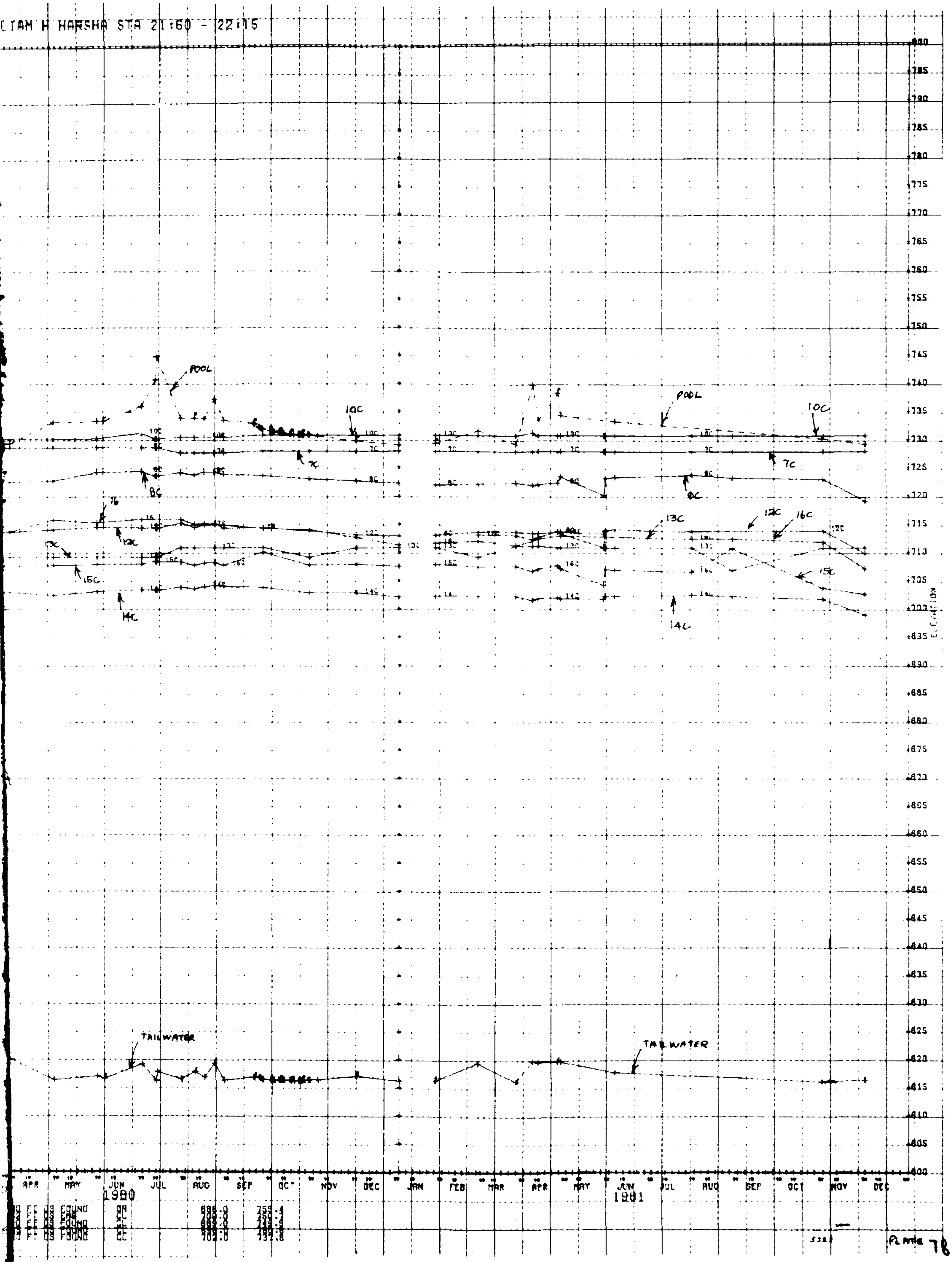
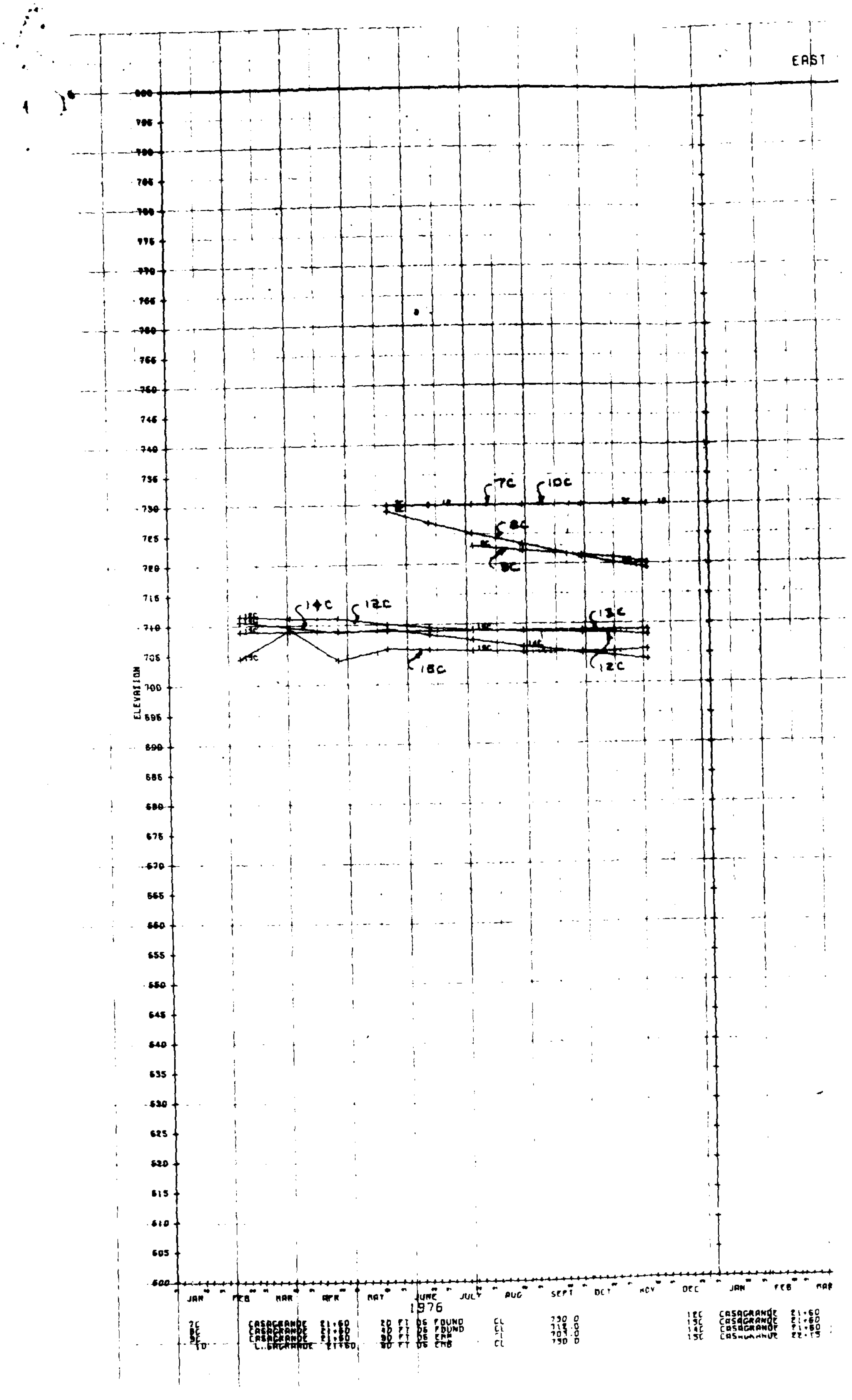
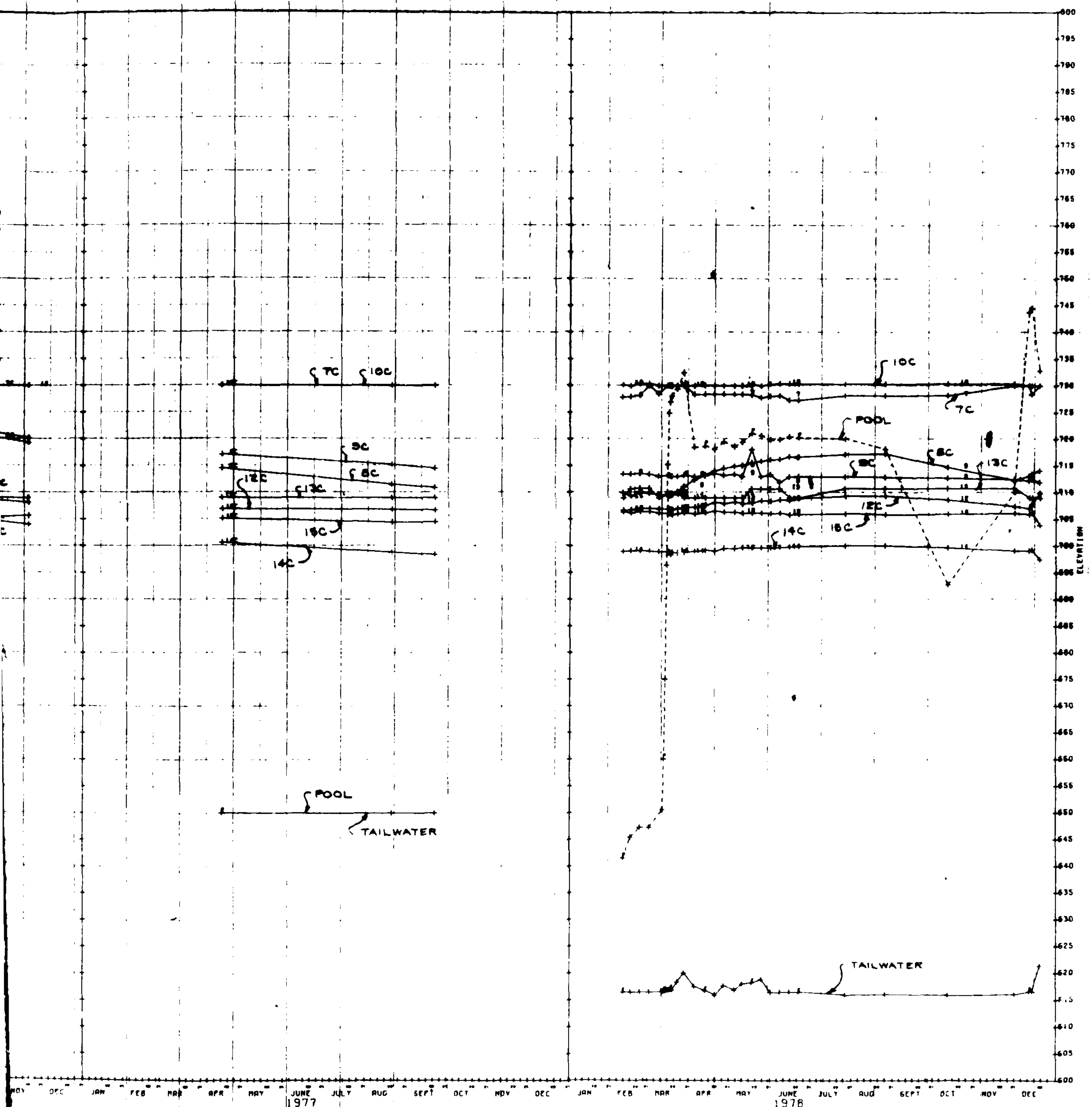

LIAM H HARSHA STA 21:60 - 22:15
POOL
10C
7C
8C
13C
12C
16C
15C
14C
TAILWATER
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB
MAR
1980
1981
ELEVATION

PLATE 78



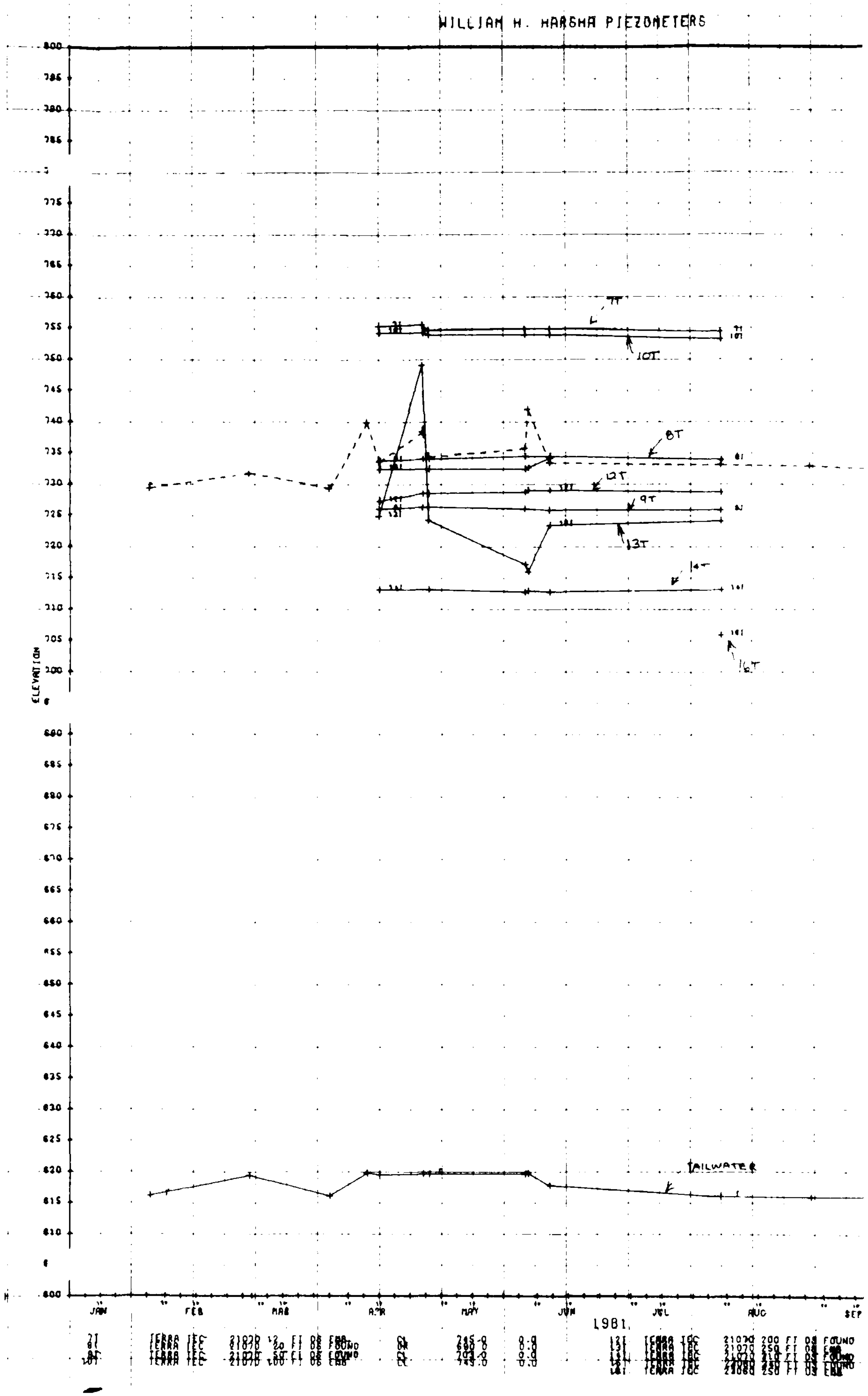
EAST
ELEVATION
800
795
790
785
780
775
770
765
760
755
750
745
740
735
730
725
720
715
710
705
700
695
690
685
680
675
670
665
660
655
650
645
640
635
630
625
620
615
610
605
600
7C
10C
8C
9C
14C
12C
13C
18C
JAN
FEB
MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
MAR
1976

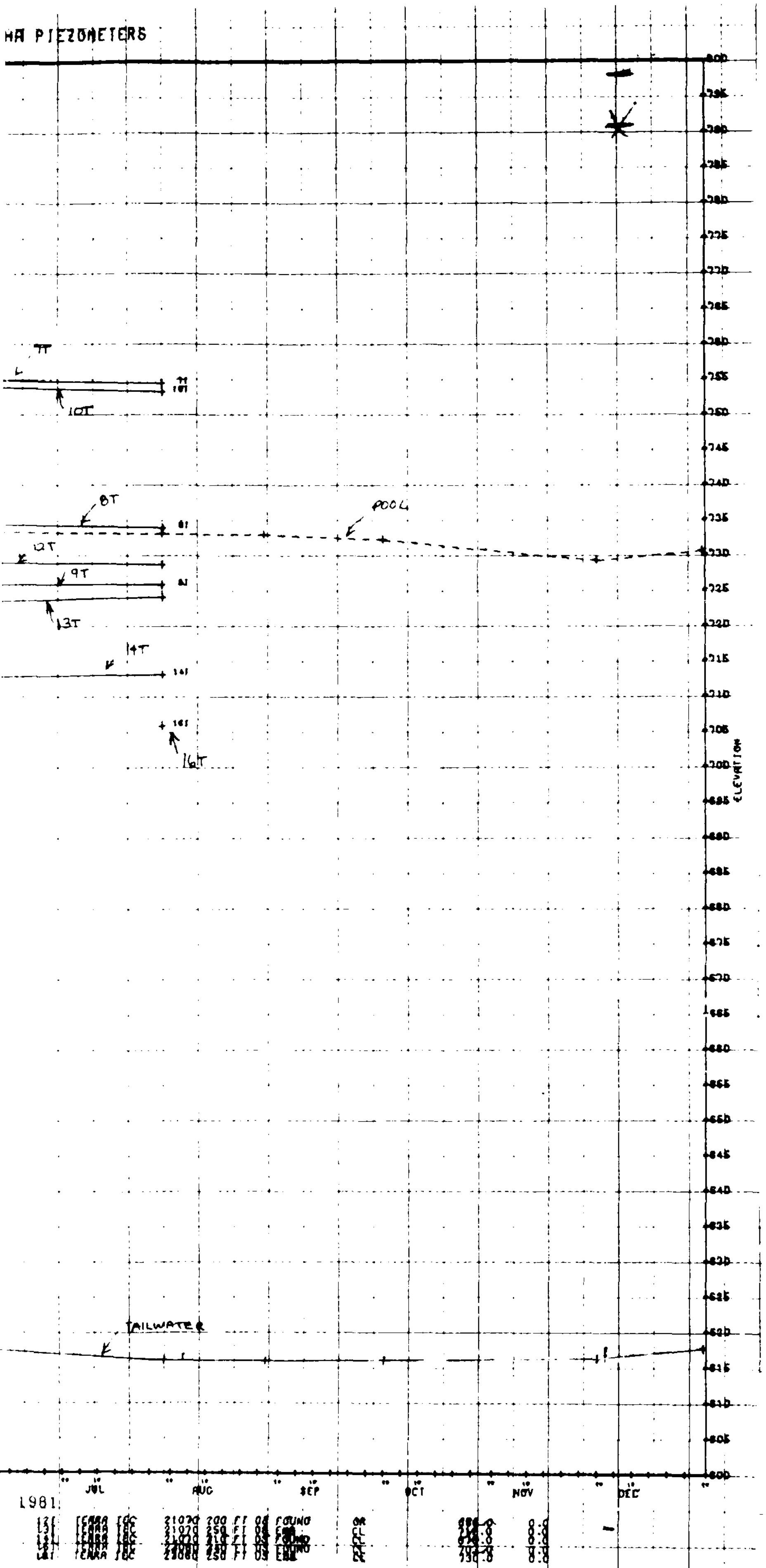
EAST FORK PIEZOMETERS STA 21+60-22+15



12C	CASAGRANDE	21+60	210 FT OS FOUND	OM	688	0
13C	CASAGRANDE	21+60	282 FT OS EMB	CL	705	0
14C	CASAGRANDE	21+60	300 FT OS FOUND	CL	685	0
15C	CASAGRANDE	22+15	283 FT OS FOUND	CL	698	0

— PLATE 19


WILLIAM H. HARSHA PIEZOMETERS
ELEVATION
800
795
790
785
775
770
765
760
755
750
745
740
735
730
725
720
715
710
705
700
690
685
680
675
670
665
660
655
650
645
640
635
630
625
620
615
610
600
7T
10T
8T
12T
11T
9T
13T
14T
16T
TAILWATER
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
1981
TERRA TEC
TERRA TEC
21070 200 FT OS FOUND



HA PIEZOMETERS
7T
10T
8T
POOL
12T
9T
13T
14T
16T
TAILWATER
ELEVATION
JUL
AUG
SEP
OCT
NOV
DEC
1981

PLATE 10

WILLIAM H. HARSHA PZS STA. 21470

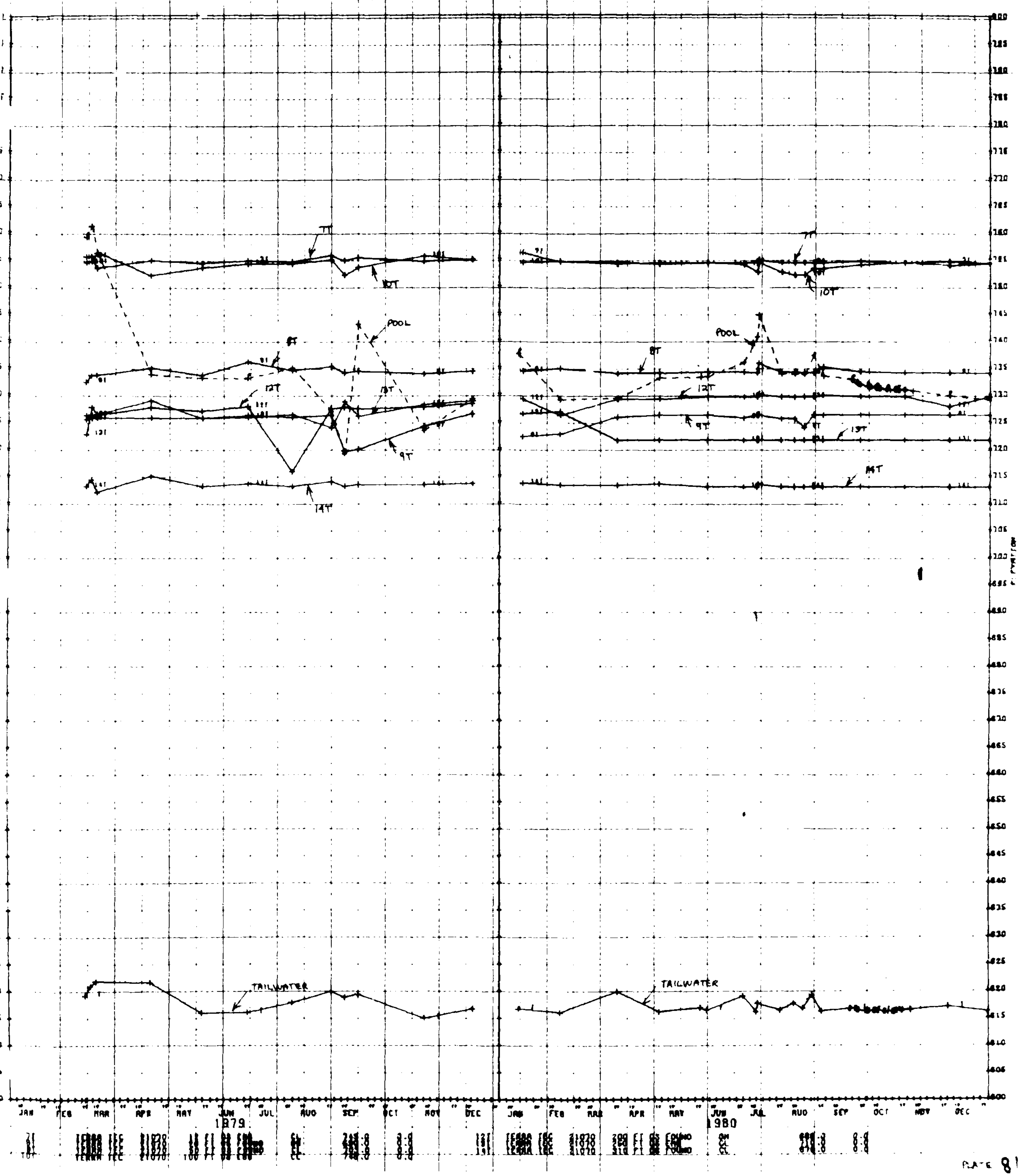
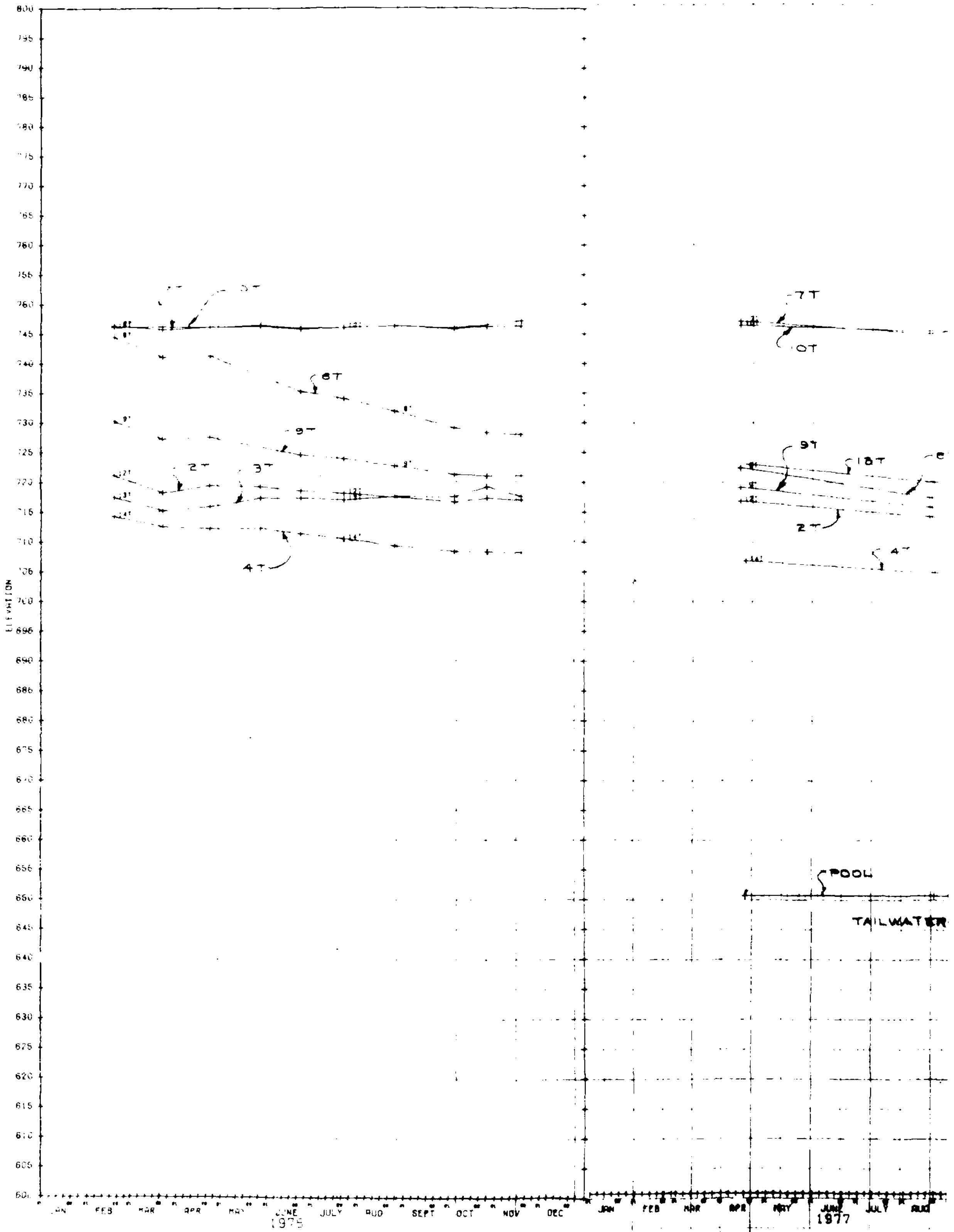


PLATE 81

EAST FORK PIEZOMETERS



8T	TERRA TEC	21+70	12 FT DS EMB	CL	745.0
9T	TERRA TEC	21+70	27 FT DS FOUND	OH	690.0
	TERRA TEC	21+70	50 FT DS FOUND	CL	703.0
	TERRA TEC	21+70	100 FT DS EMB	CL	745.0
12T	TERRA TEC	21+70			
13T	TERRA TEC	21+70			
14T	TERRA TEC	21+70			

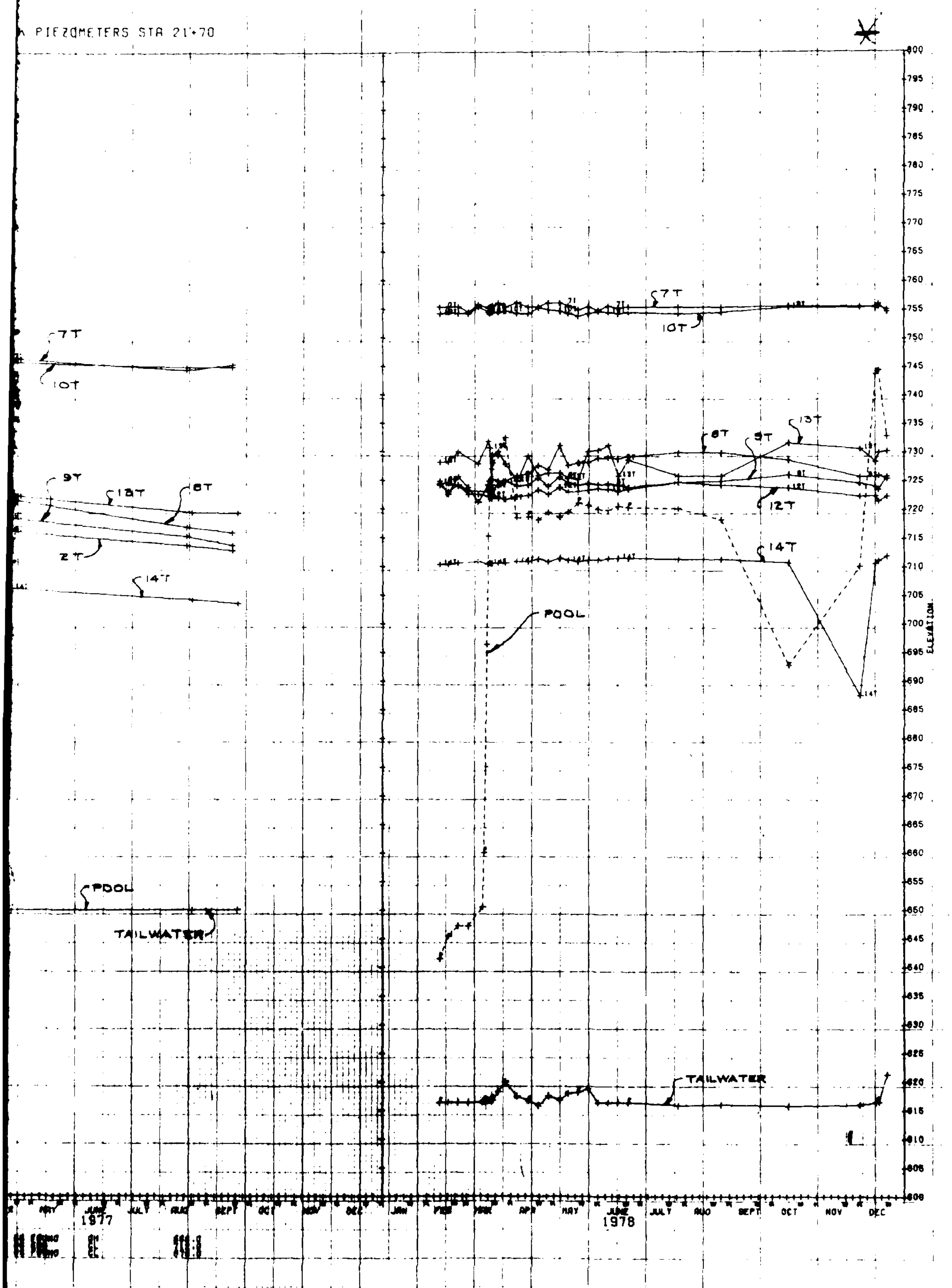
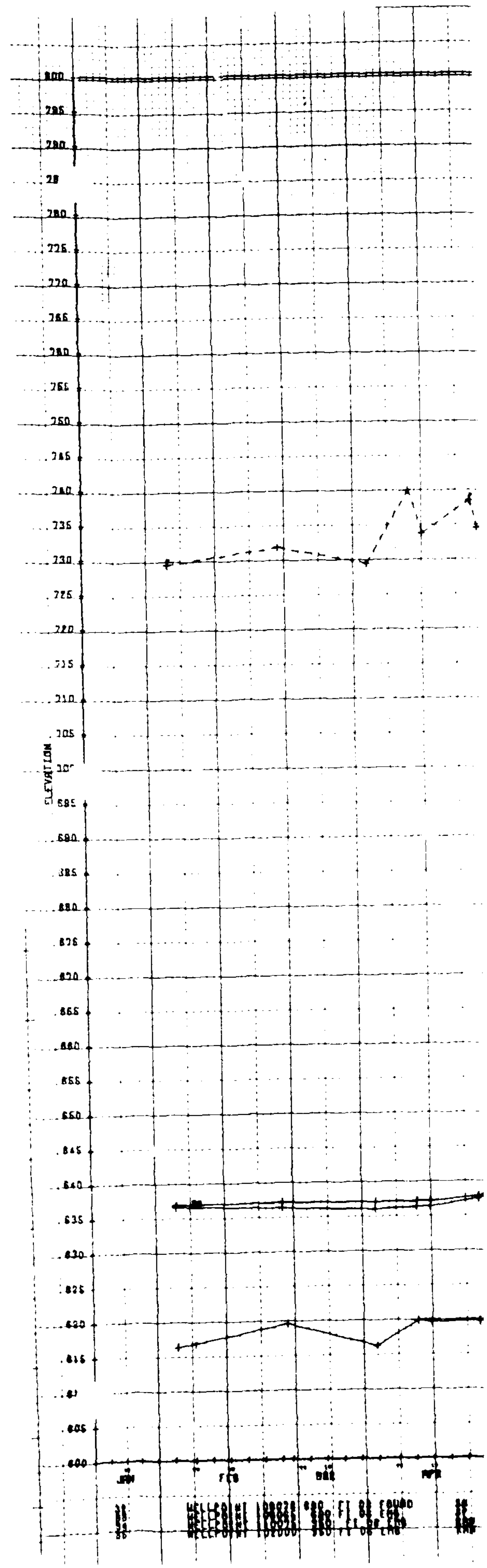

PIEZOMETERS STA 21+70
7T
10T
9T
13T
8T
2T
14T
12T
POOL
TAILWATER
ELEVATION
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
MAR
APR
1977
1978

PLATE 82


ELEVATION
JAN
FEB

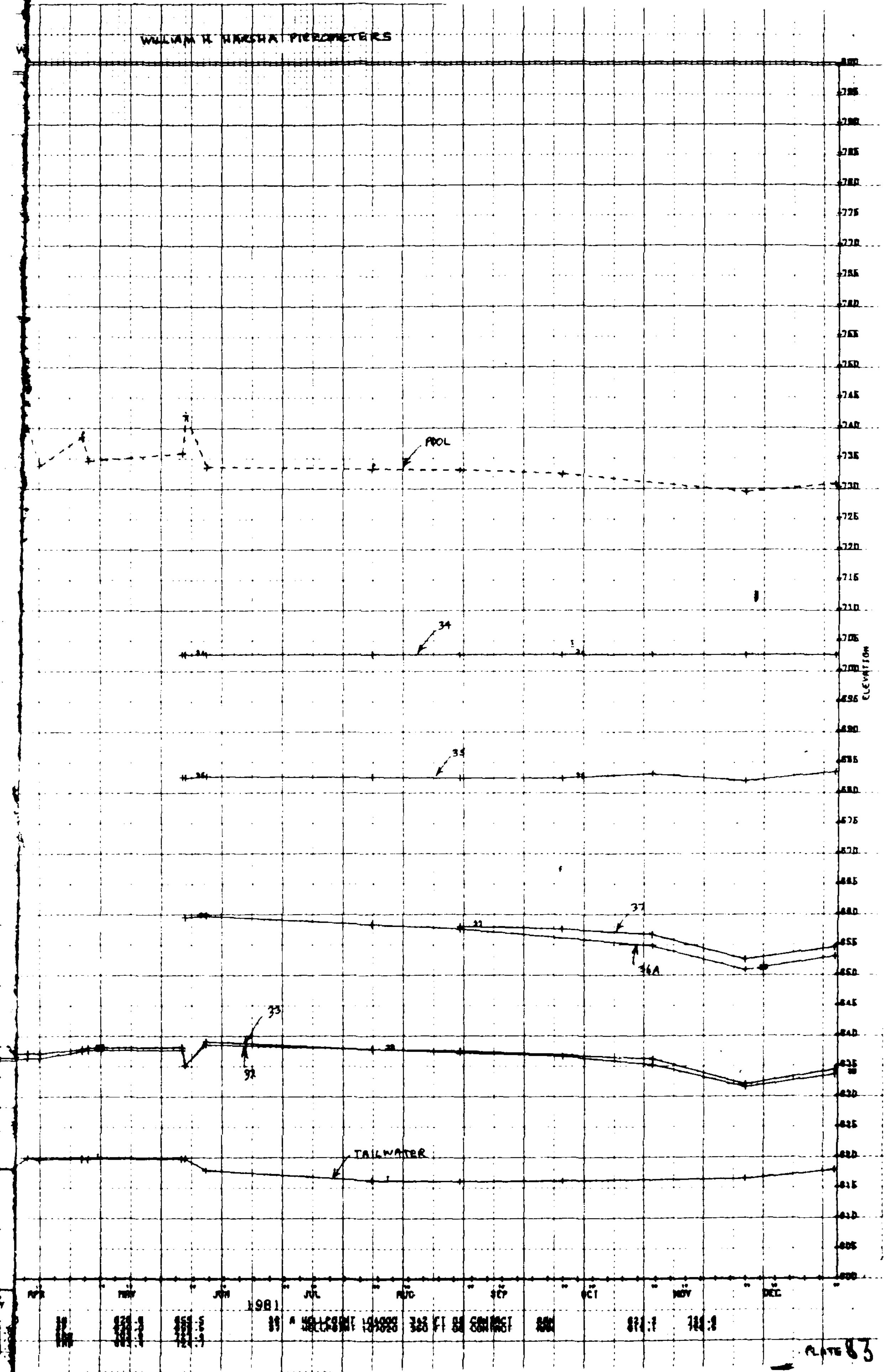
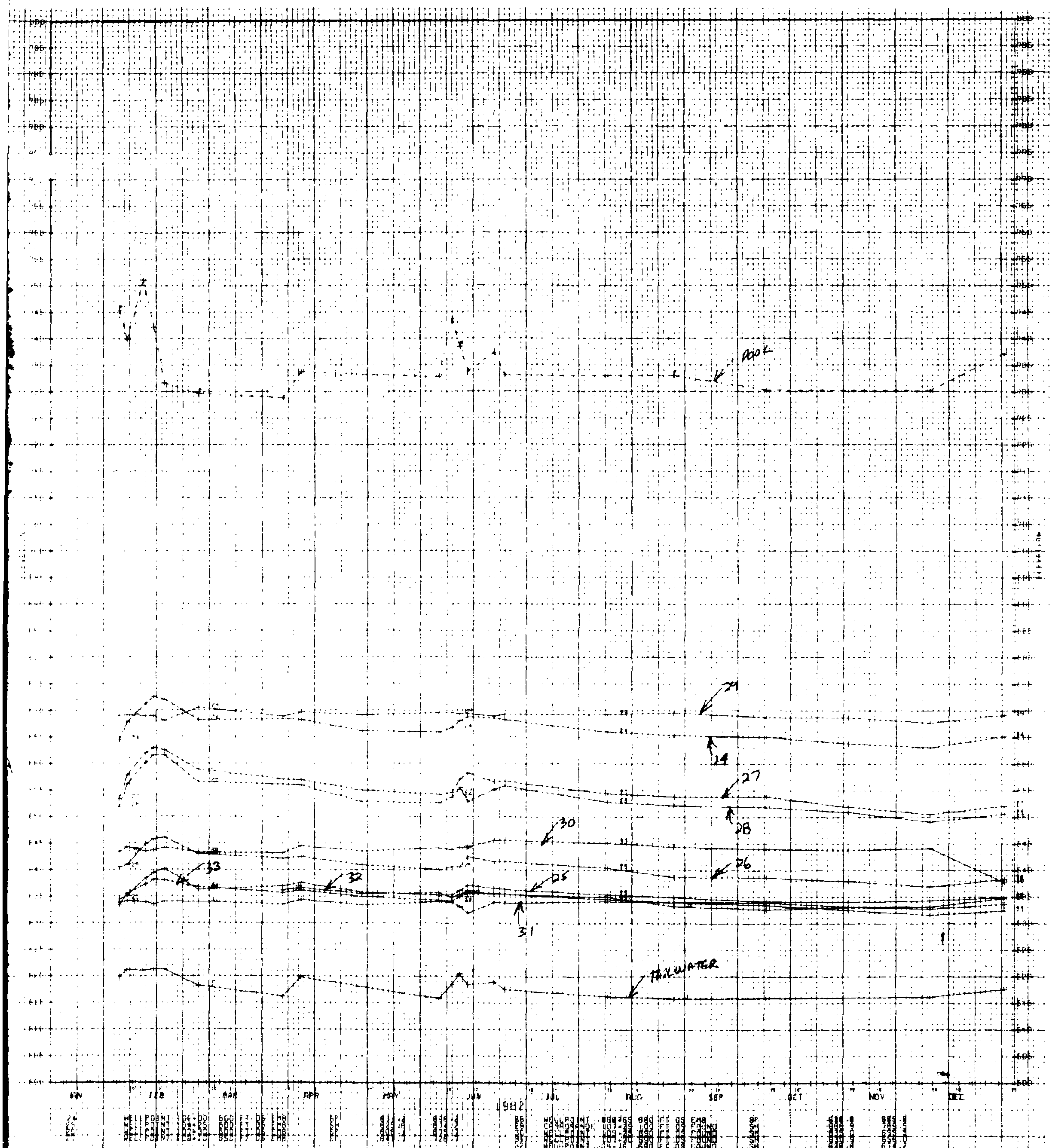

WILLIAM H. HARSHA PIEZOMETERS
POOL
34
35
37
36A
33
32
TAILWATER
ELEVATION
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
1981

PLATE 83

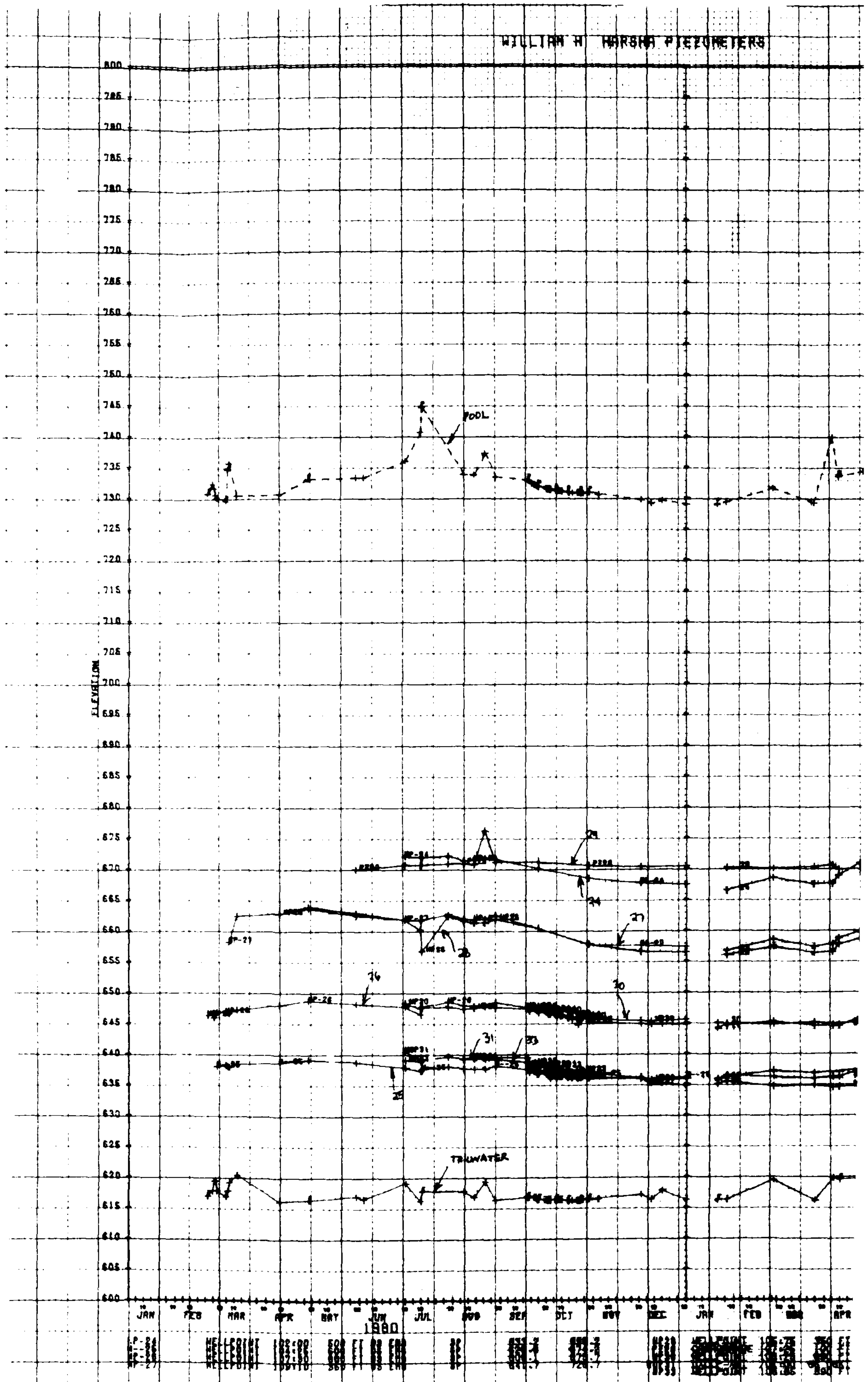


WILLIAM H. HARSHA DAM PIEZOMETERS

YEARS 82

PIEZ 24 25 26 27 28 29 30 31

PLATE 8



WILLIAM H HARSHA PIEZOMETERS
ELEVATION
800
795
790
785
780
775
770
765
760
755
750
745
740
735
730
725
720
715
710
705
700
695
690
685
680
675
670
665
660
655
650
645
640
635
630
625
620
615
610
605
600
POOL
TAILWATER
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB
APR
1980

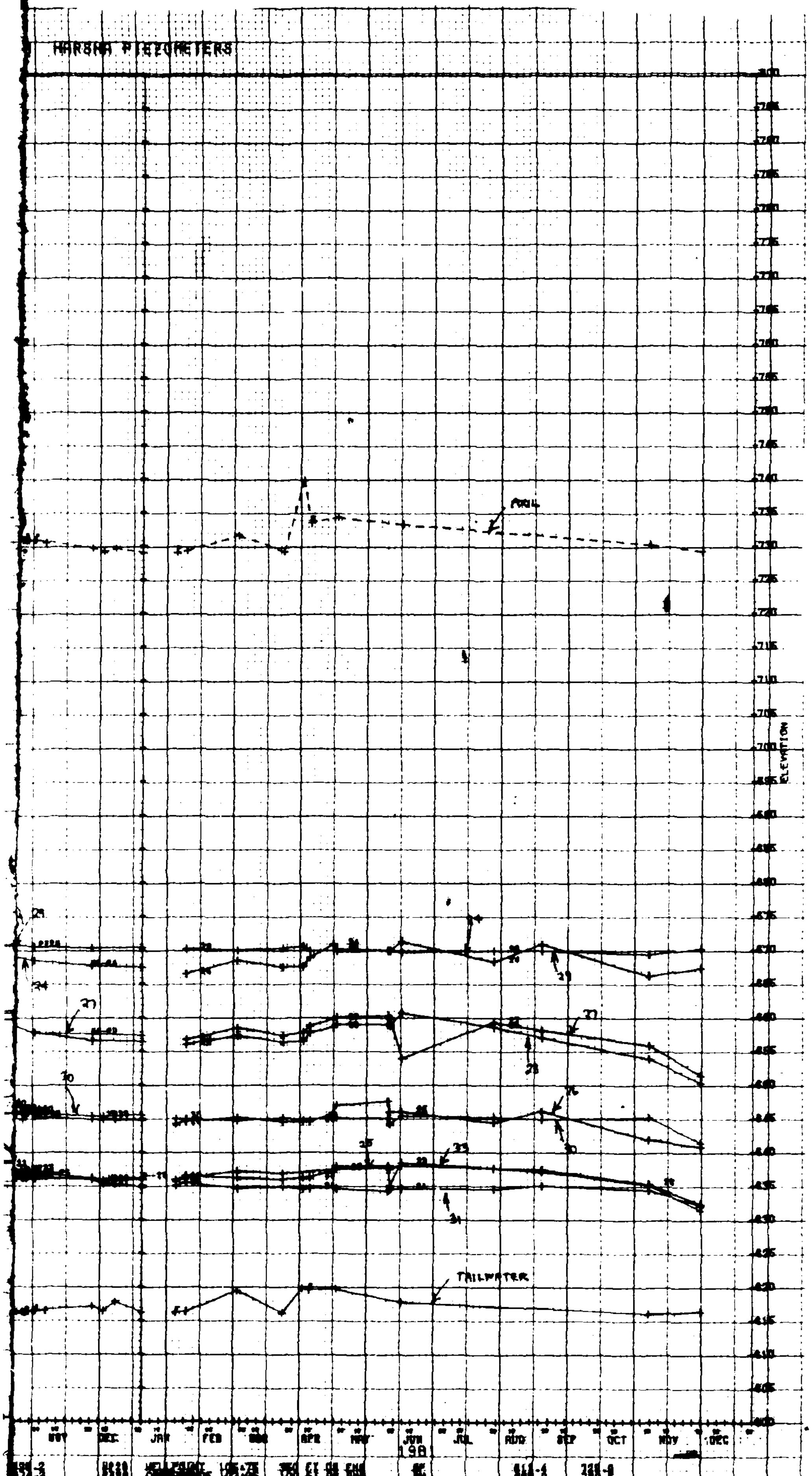
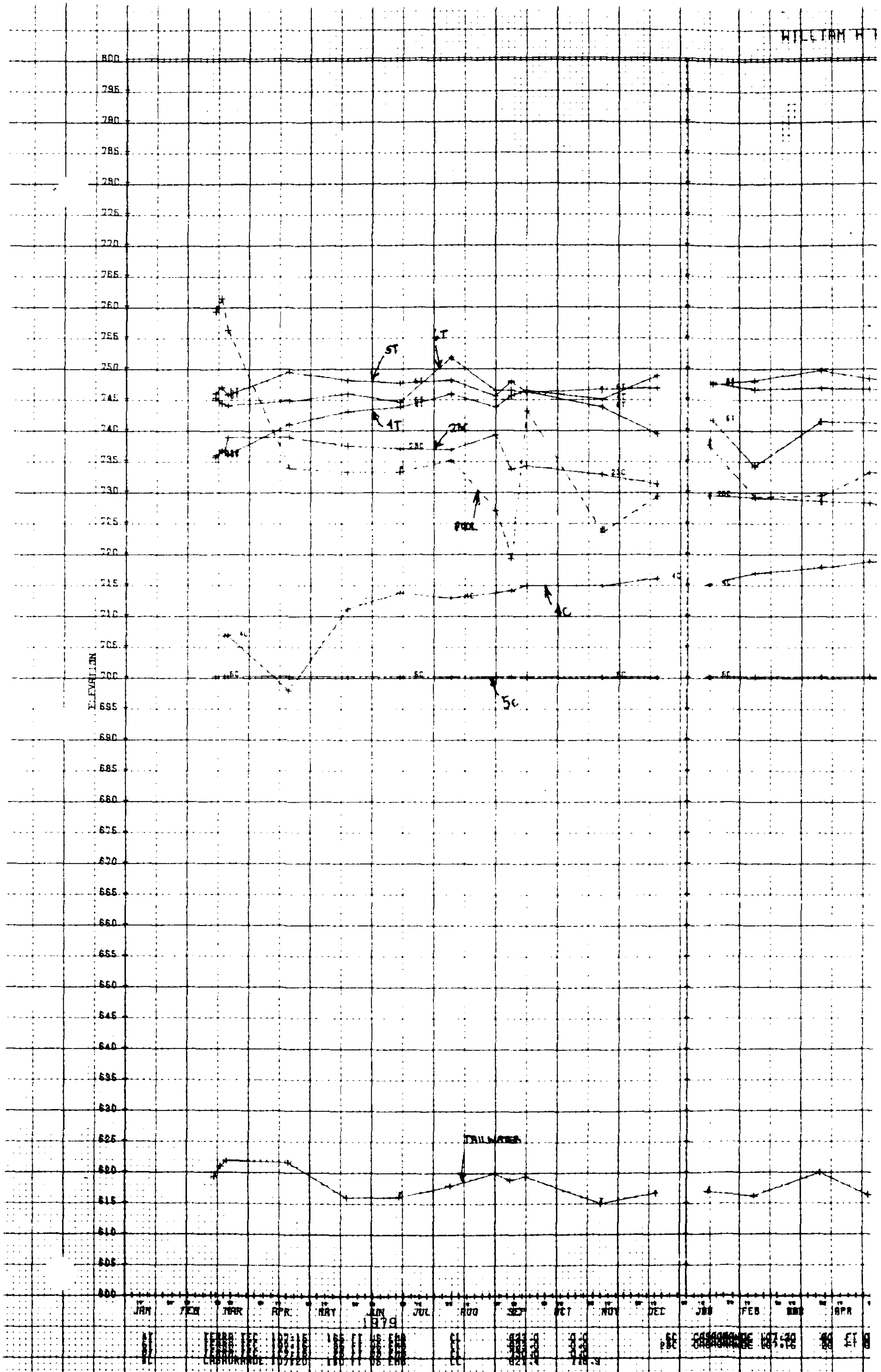
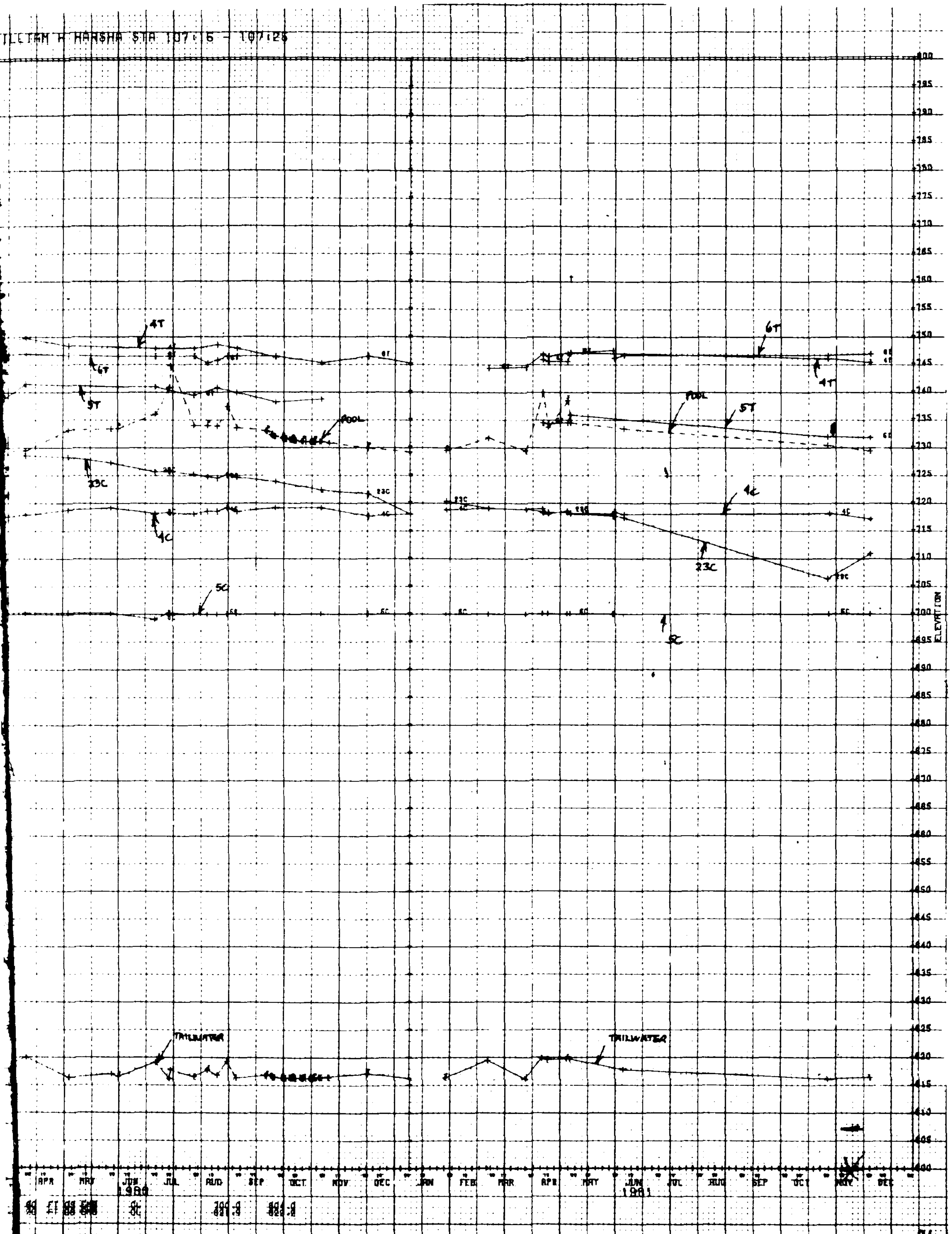

HARSHA PIEZOMETERS
POOL
TAILWATER
ELEVATION
NOV
DEC
JAN
FEB
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
1981

PLATE 85

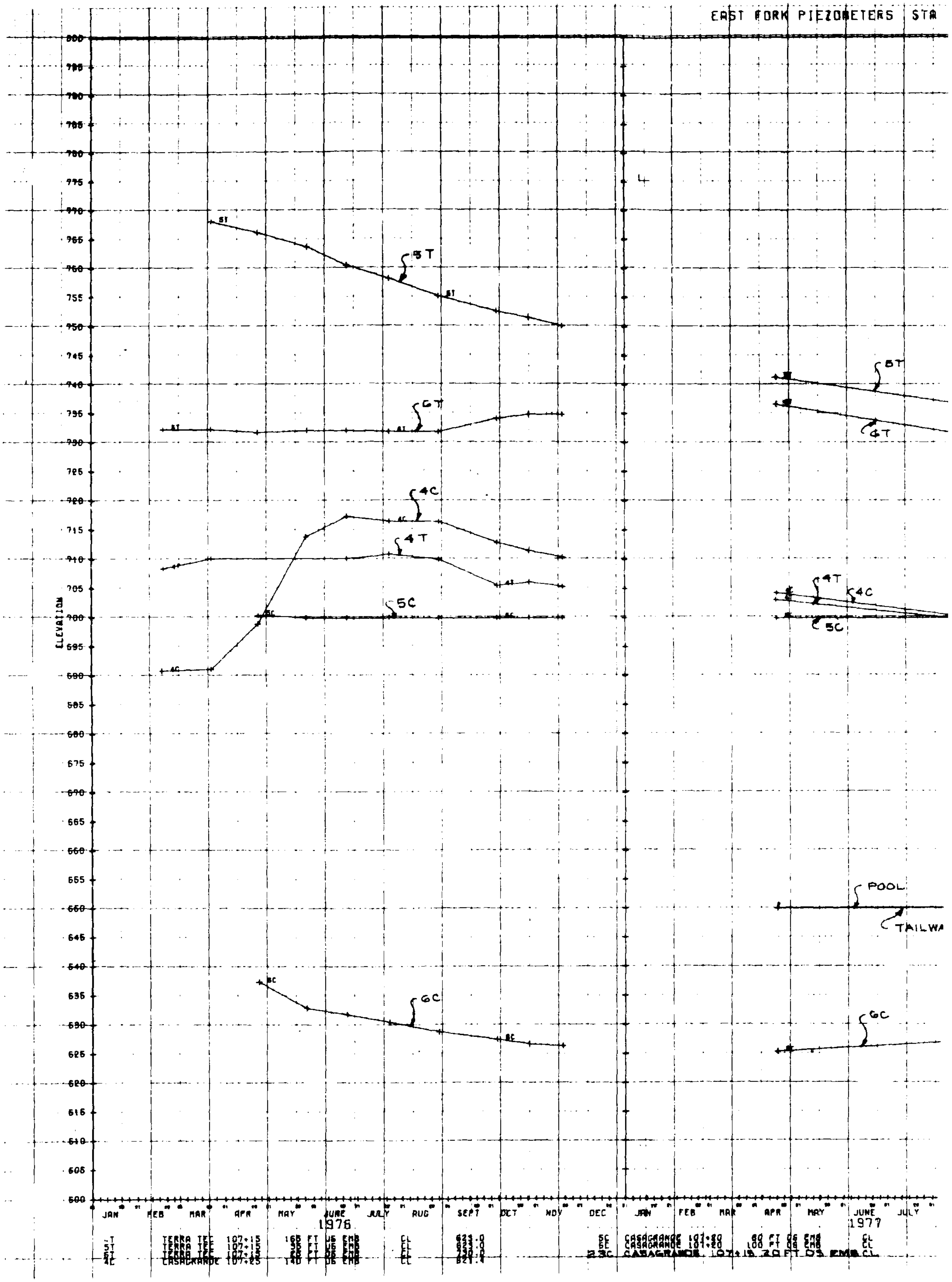


WILLIAM H
ELEVATION
800
795
790
785
780
775
770
765
760
755
750
745
740
735
730
725
720
715
710
705
700
695
690
685
680
675
670
665
660
655
650
645
640
635
630
625
620
615
610
605
600
5T
1T
4T
2M
POOL
4C
5C
TAILWATER
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
FEB
APR
1979

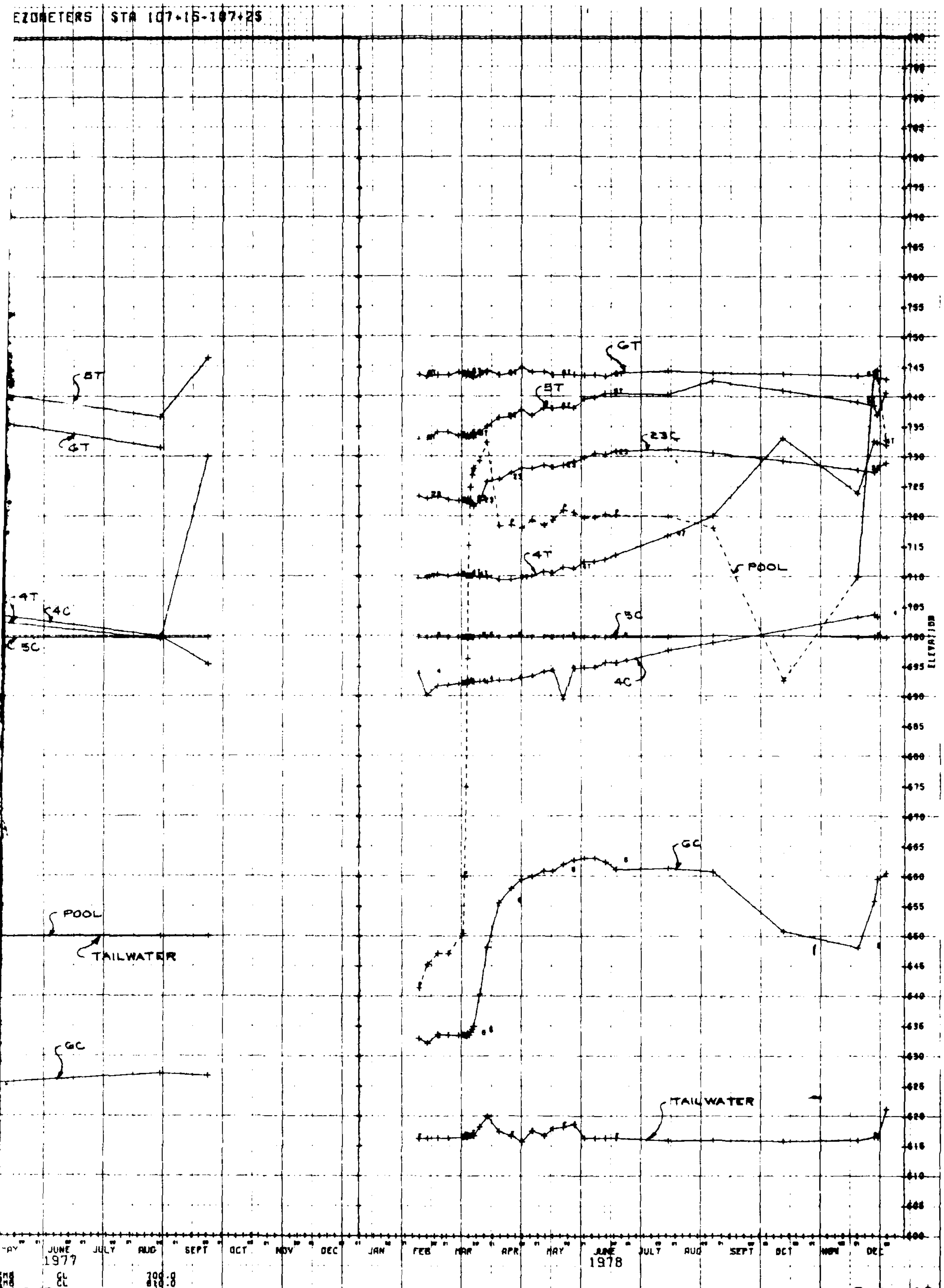


ILLIAM H HARSHA STA 107+15 - 107+25
4T
6T
5T
POOL
23C
4C
5C
TAILWATER
ELEVATION
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
1980
1981

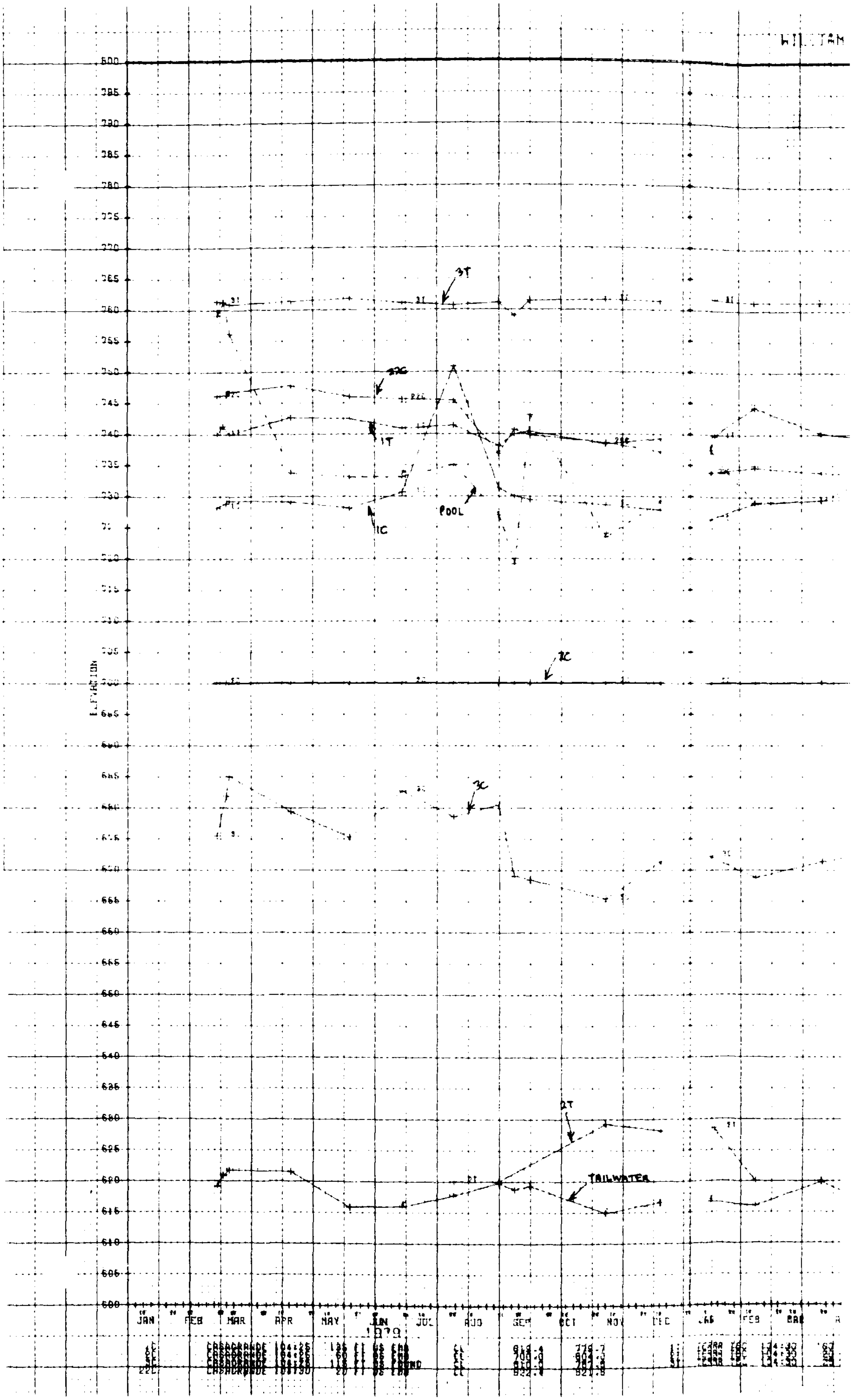
PLATE



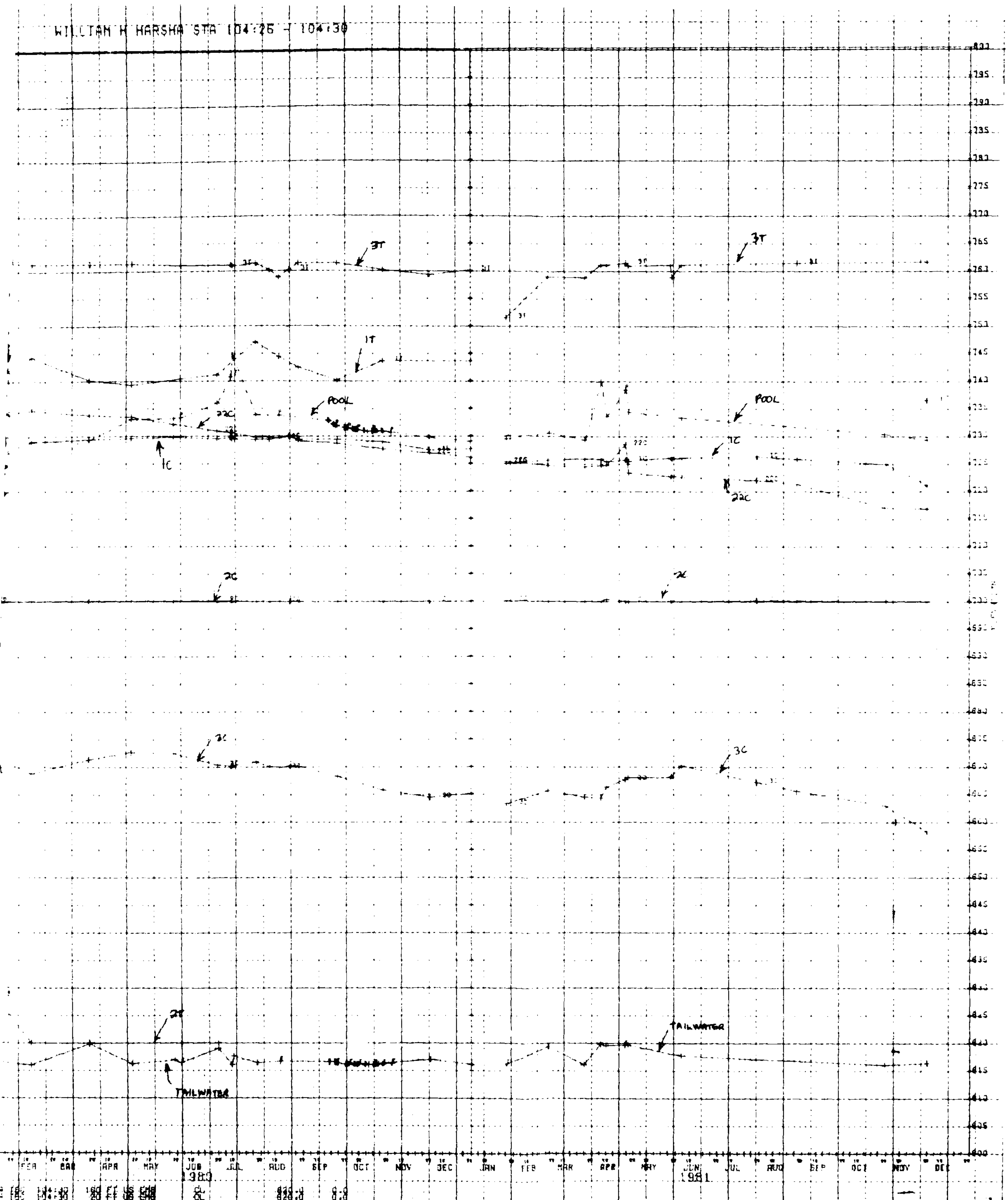
EAST FORK PIEZOMETERS STA
ELEVATION
800
795
790
785
780
775
770
765
760
755
750
745
740
735
730
725
720
715
710
705
700
695
690
685
680
675
670
665
660
655
650
645
640
635
630
625
620
615
610
605
600
5T
6T
4C
4T
5C
6C
POOL
TAILWA
JAN FEB MAR APR MAY JUNE JULY AUG SEPT OCT NOV DEC
1976
JAN FEB MAR APR MAY JUNE JULY
1977
TERRA TEC 107+15 165 FT US EMB CL 623.0
5T TERRA TEC 107+15 35 FT US EMB CL 623.0
6T TERRA TEC 107+15 25 FT DS EMB CL 730.0
4C CASAGRANDE 107+25 140 FT DS EMB CL 621.4
5C CASAGRANDE 107+20 60 FT DS EMB CL
6C CASAGRANDE 107+20 100 FT DS EMB CL
23C CASAGRANDE 107+15 20 FT DS EMB CL


EZOMETERS STA 107+15-107+25
6T
5T
23C
4T
4C
5C
POOL
TAILWATER
GC
ELEVATION
JUNE 1977
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUNE 1978
JULY
AUG
SEPT
OCT
NOV
DEC

PLATE

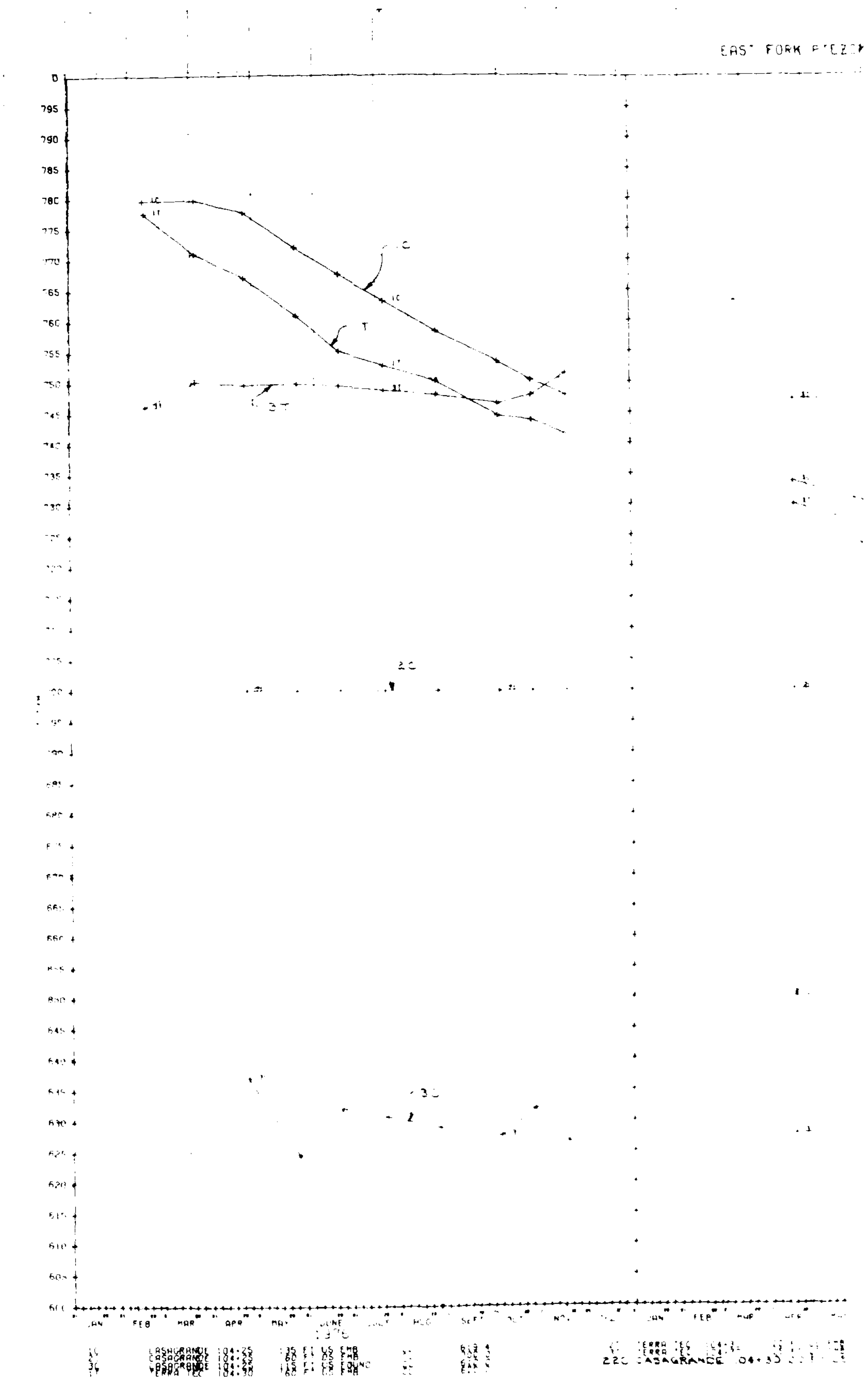


ELEVATION
3T
32C
1T
1C
POOL
2C
3C
2T
TAILWATER
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
1979



WILLIAM H HARSHA STA 104:26 - 104:30
3T
1T
POOL
22C
1C
2C
3C
2T
TAILWATER
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
1980
1981

PLATE


EAST FORK PIEZ
1976
CASAGRANDE 104+25 135 FT US EMB
CASAGRANDE 104+25 60 FT DS EMB
CASAGRANDE 104+25 115 FT US FOUND
TERRA TEC 104+30 60 FT DS EMB
22C CASAGRANDE 104+35

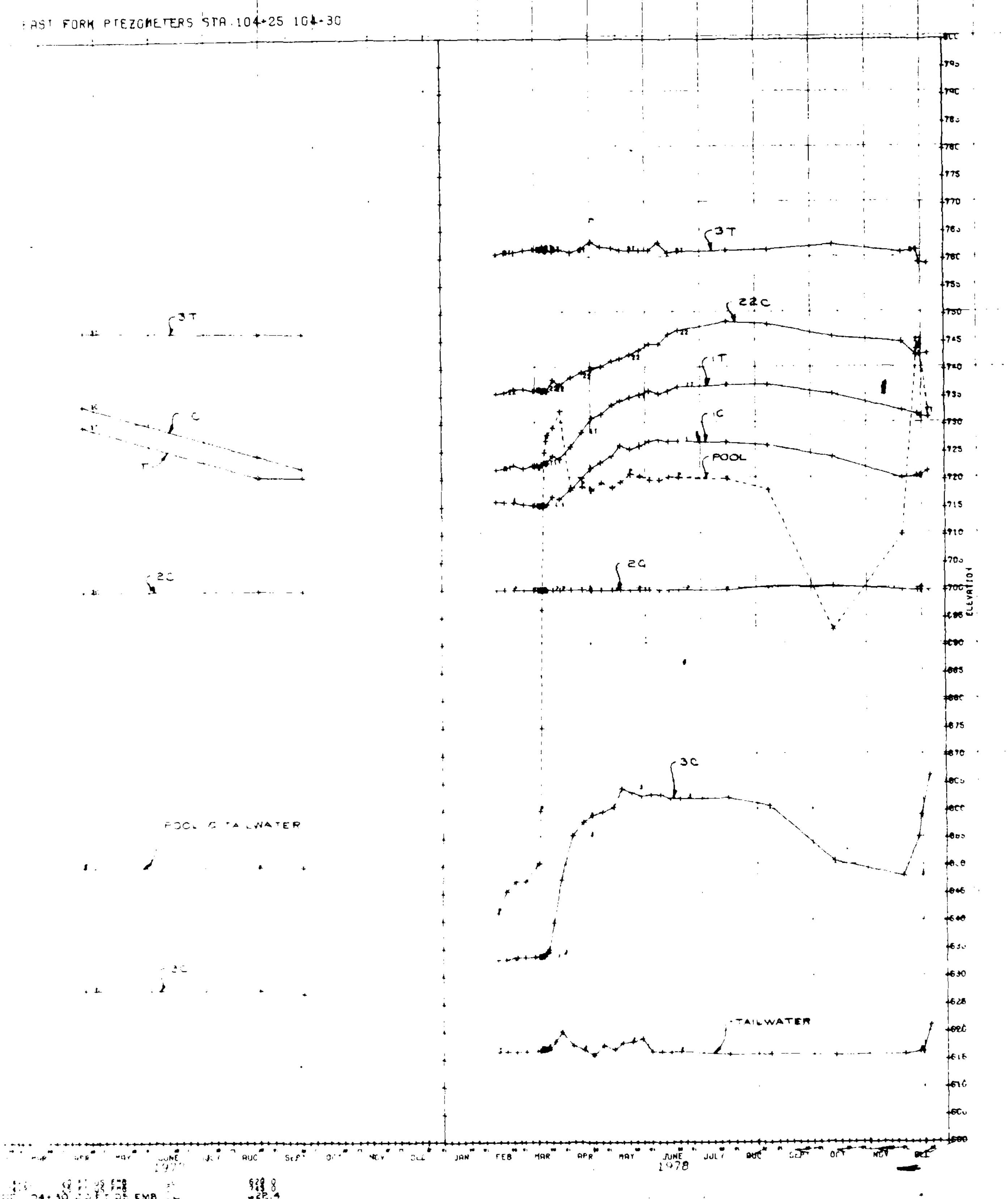
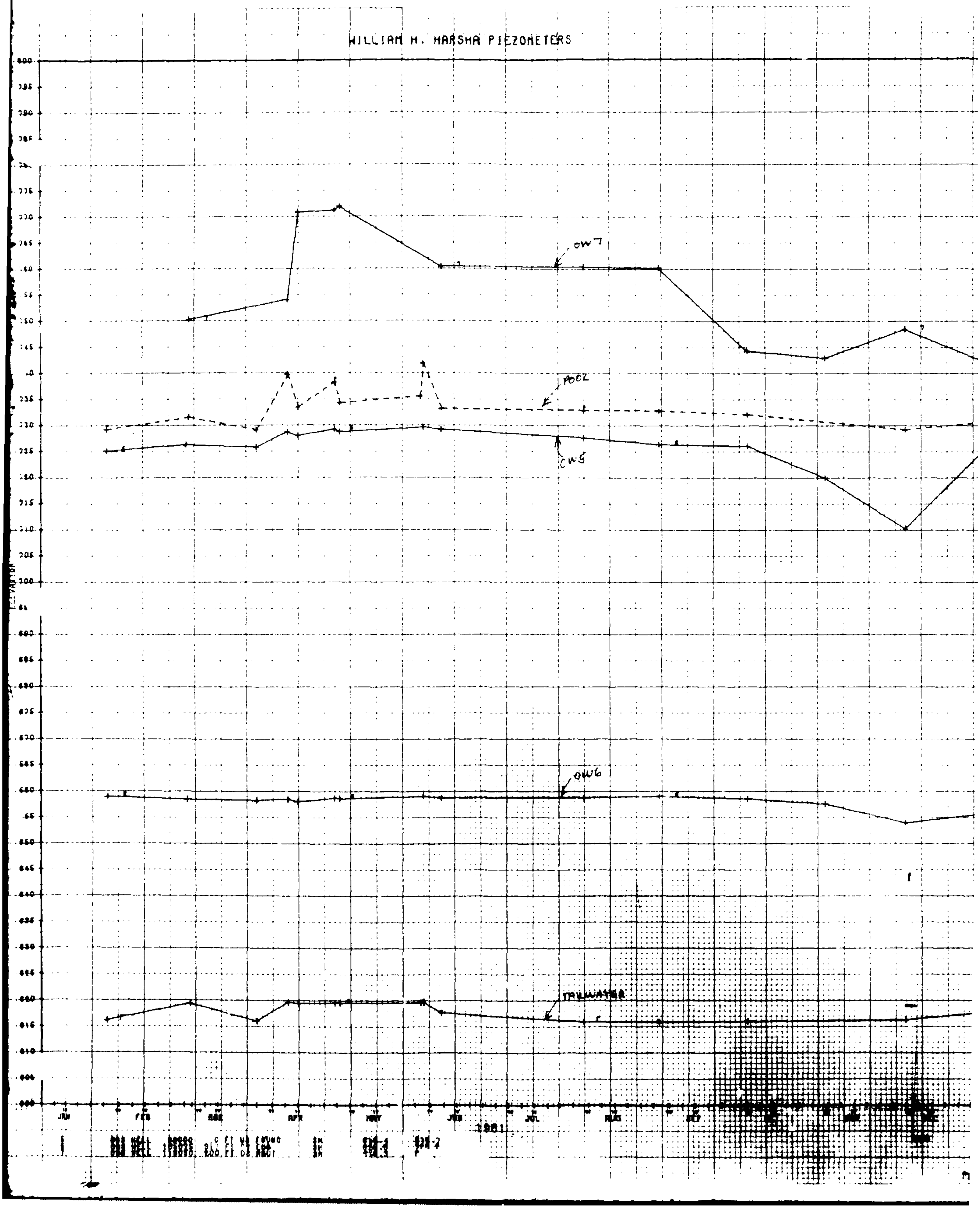
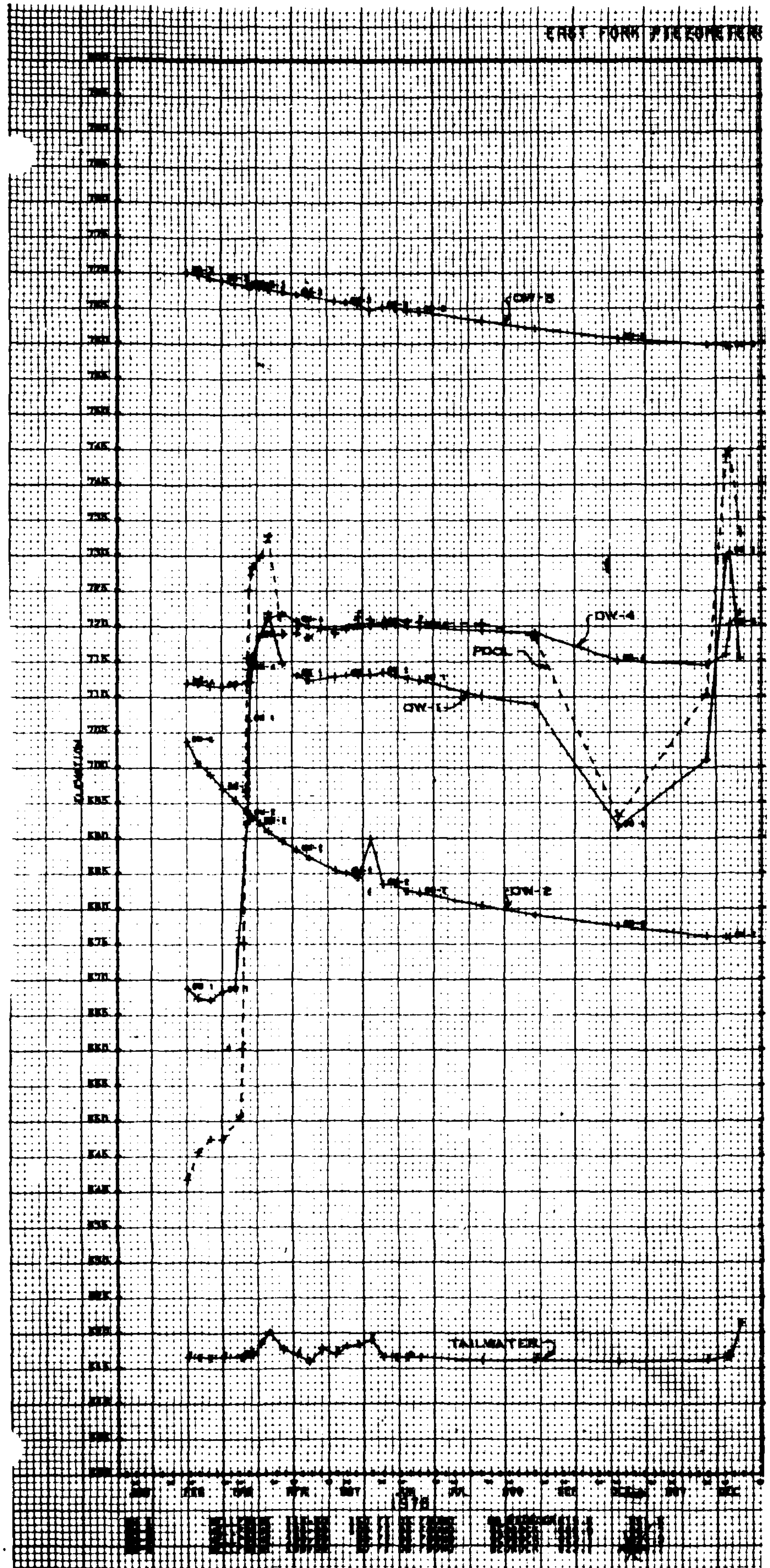

EAST FORK PIEZOMETERS STA.104+25 104+30
3T
22C
1T
1C
POOL
2C
3C
TAILWATER
POOL & TAILWATER
JAN
FEB
MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
1978
ELEVATION

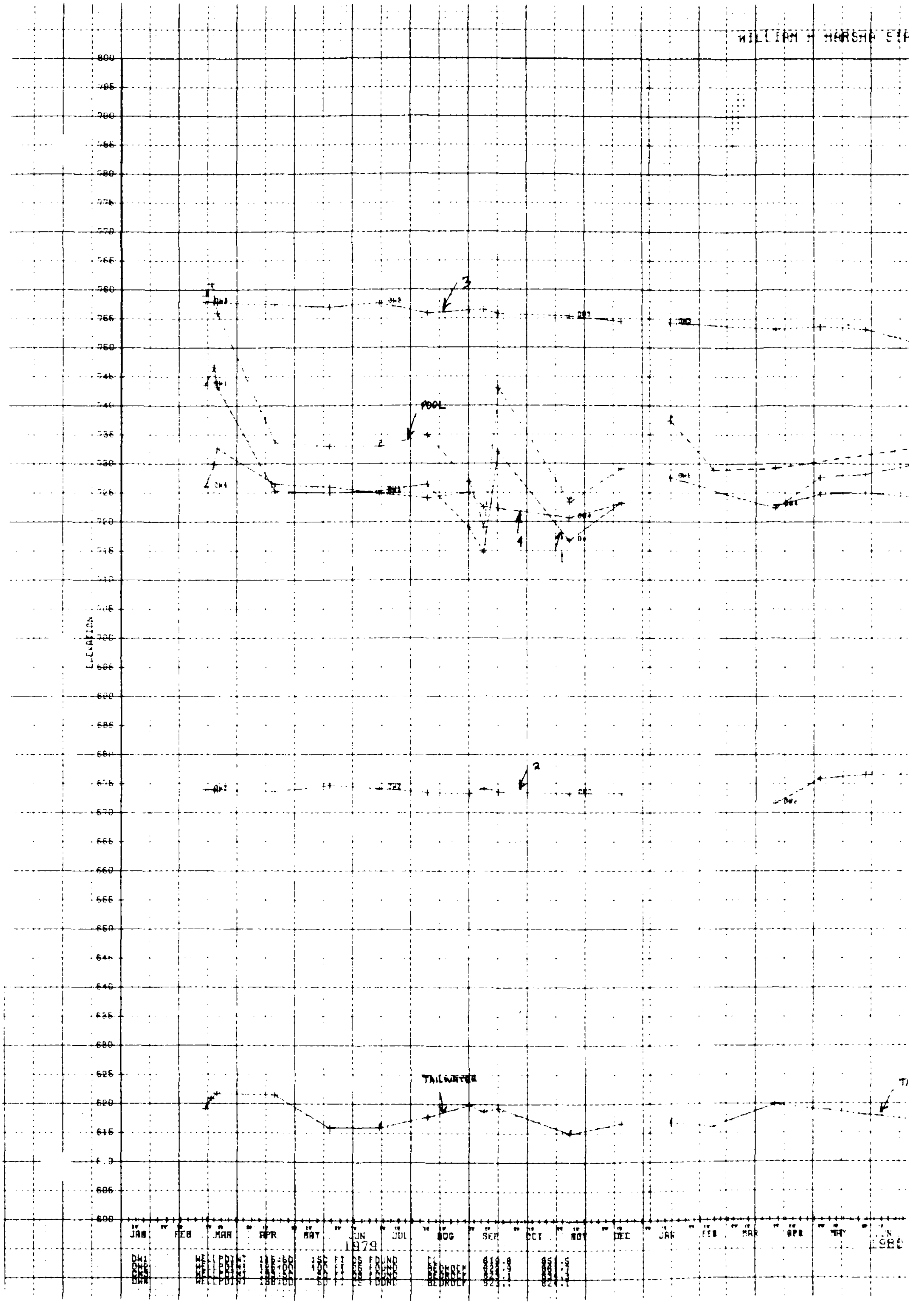
PLATE 89


WILLIAM H. HARSHA PIEZOMETERS
OW7
POOL
OW5
OW6
TAILWATER
ELEVATION
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
1981



EAST FORK PIEZOMETERS
OW-5
OW-4
POOL
OW-1
OW-2
TAILWATER
ELEVATION
1978

PLATE 9



WILLIAM H HARSHA
POOL
TAILWATER
ELEVATION
800
780
760
755
750
740
730
720
700
690
680
670
660
650
640
630
620
615
605
600
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
1979
DW1
WELLPOINT
150 FT DS FOUND
BEDROCK

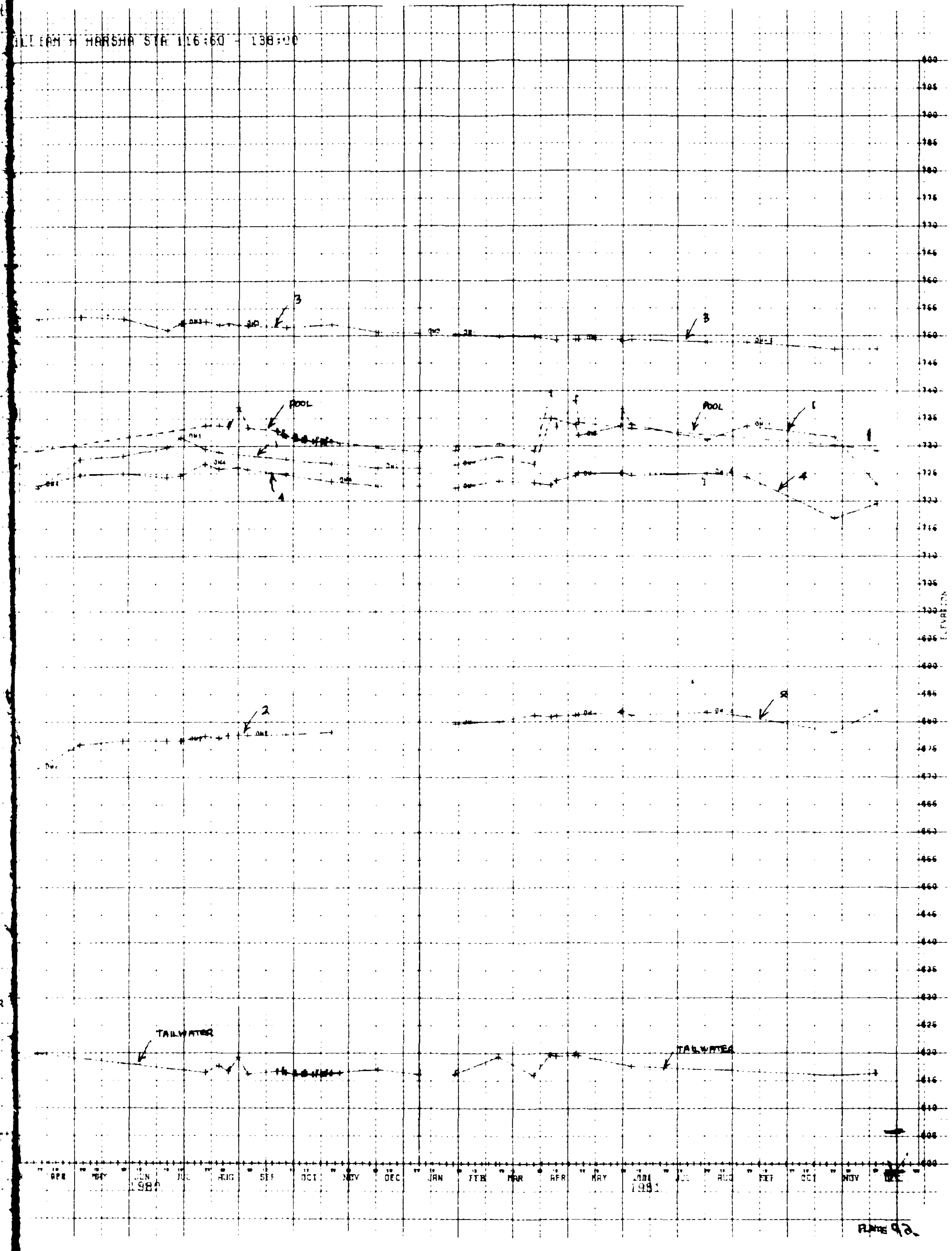
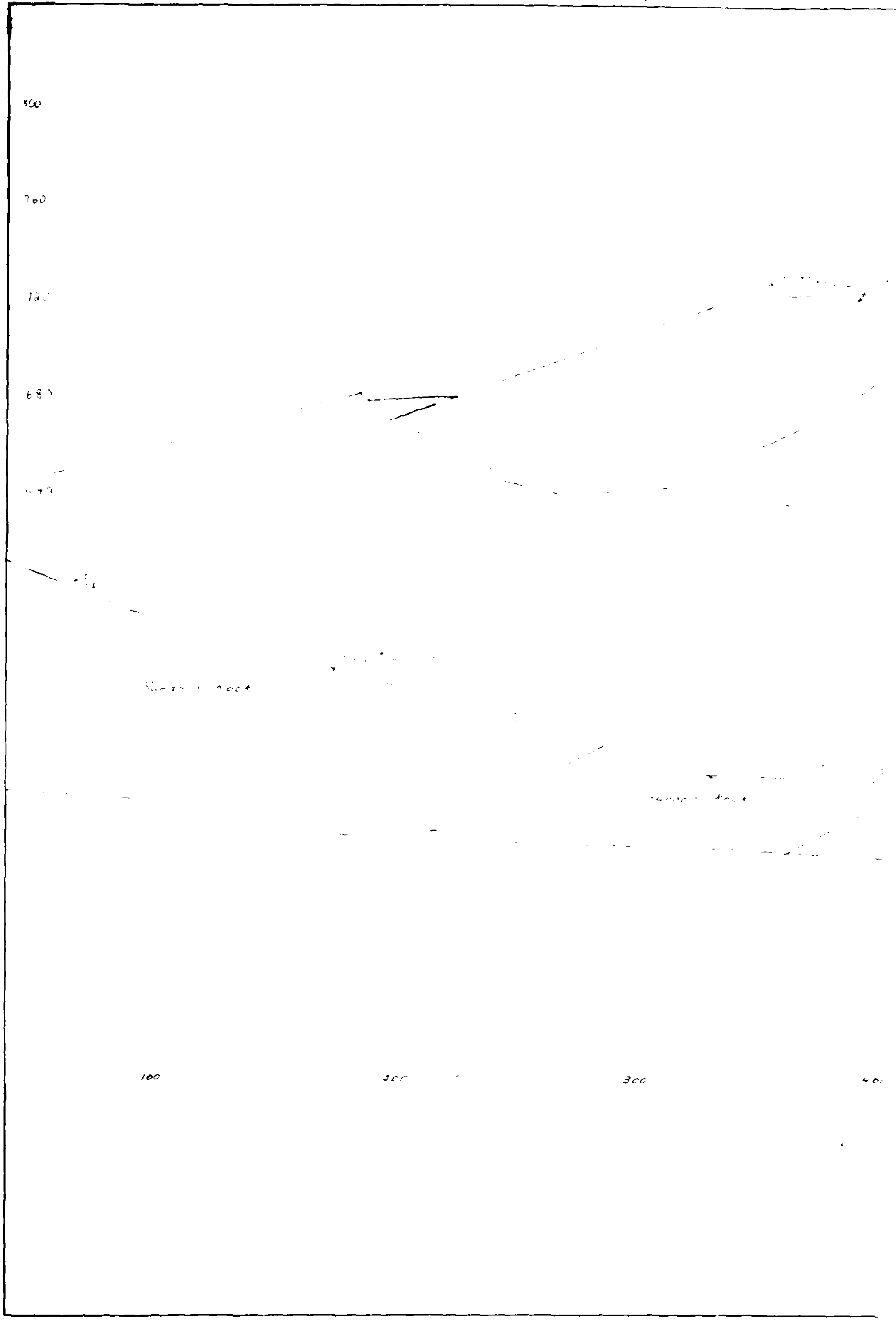
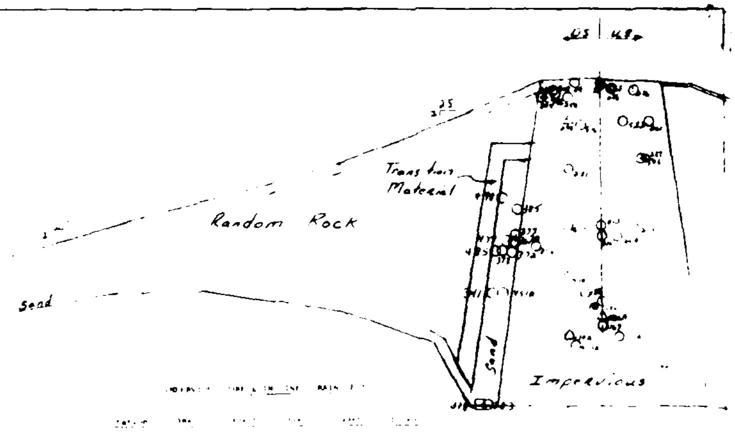

LLIAM H HARSHA STA 116:60 - 138:00
POOL
POOL
TAILWATER
TAILWATER
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
ELEVATION

PLATE 92

CORPS OF ENGINEERS



U S ARMY



LEFT ABUTMENT SAND BLANKET DENSITY TESTS

Station	99+[illegible]	99+[illegible]	99+[illegible]	100+00	100+15	100+25	100+[illegible]	100+[illegible]	100+65	100+7[illegible]	100+80	100+90	100+95
Test #	[illegible]	[illegible]	[illegible]	[illegible] [illegible] 14 [illegible]	442A	[illegible]	[illegible] 114A	239 261 [illegible]38 150 259 492A 379 321	[illegible] 4[illegible] 41[illegible]	118 4[illegible]	394A 414A 480A 164A	362	244A

Station	[illegible]	[illegible]	[illegible]	[illegible]	101+3[illegible]	[illegible]	101+5[illegible]	101+5[illegible]	101+60	101+7[illegible]	101+8[illegible]	101+9[illegible]
Test #	[illegible] 19[illegible] [illegible] 19[illegible] 28[illegible] [illegible]95A	246 409 [illegible] 14 144	[illegible] 278 419A [illegible]	[illegible] 343 [illegible] 2[illegible]9 29[illegible]	113A	[illegible]4A	102 115 147A 265A 110 117 147A 353	357A 242A 257A 374A 383 265A 280 282	32[illegible] 372 2[illegible]	111 248A 365	137 2[illegible]	314 222

800

760

720

680

640

400 500 600 700

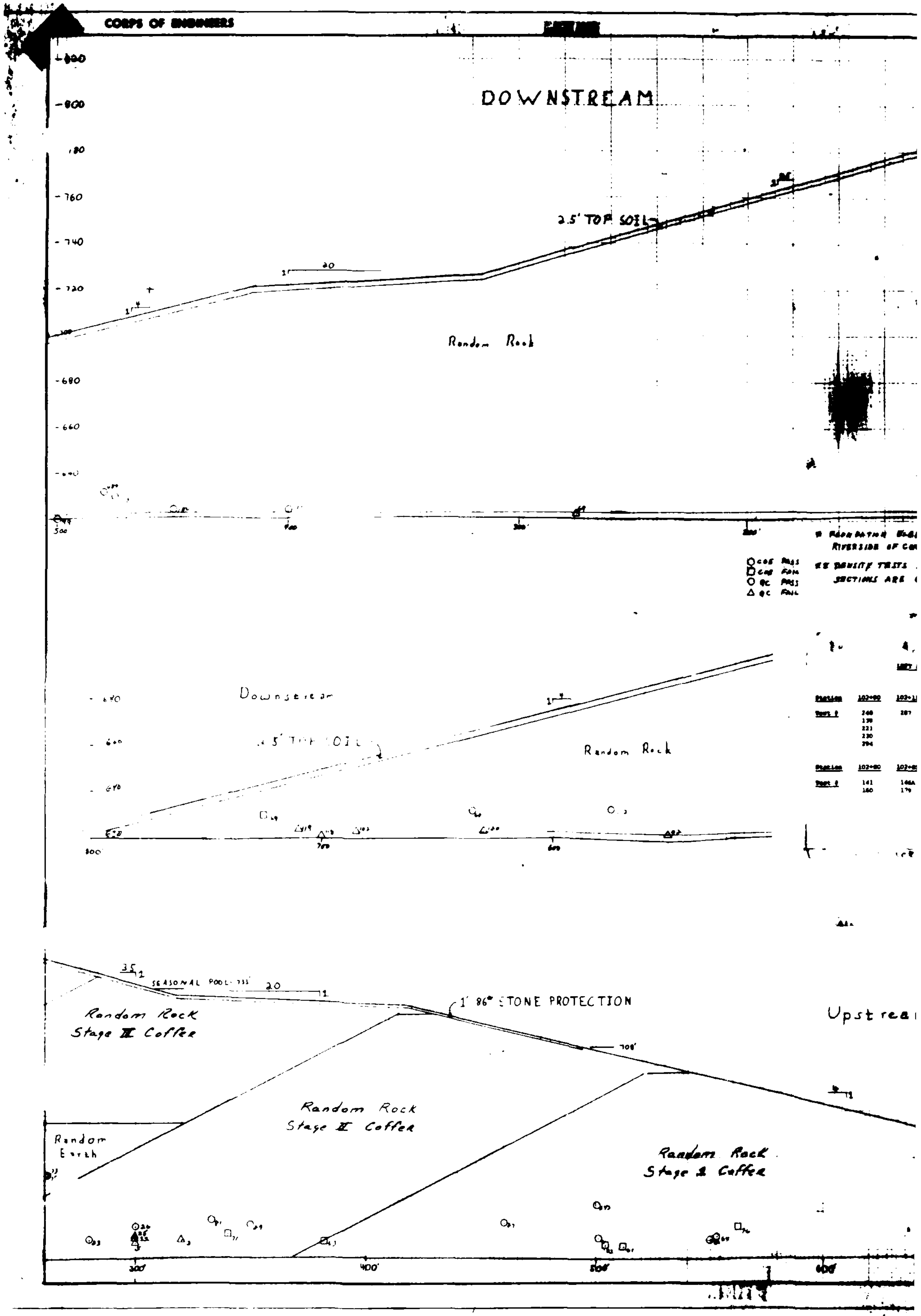
REVISION	DATE	DESCRIPTION	BY	APP'D

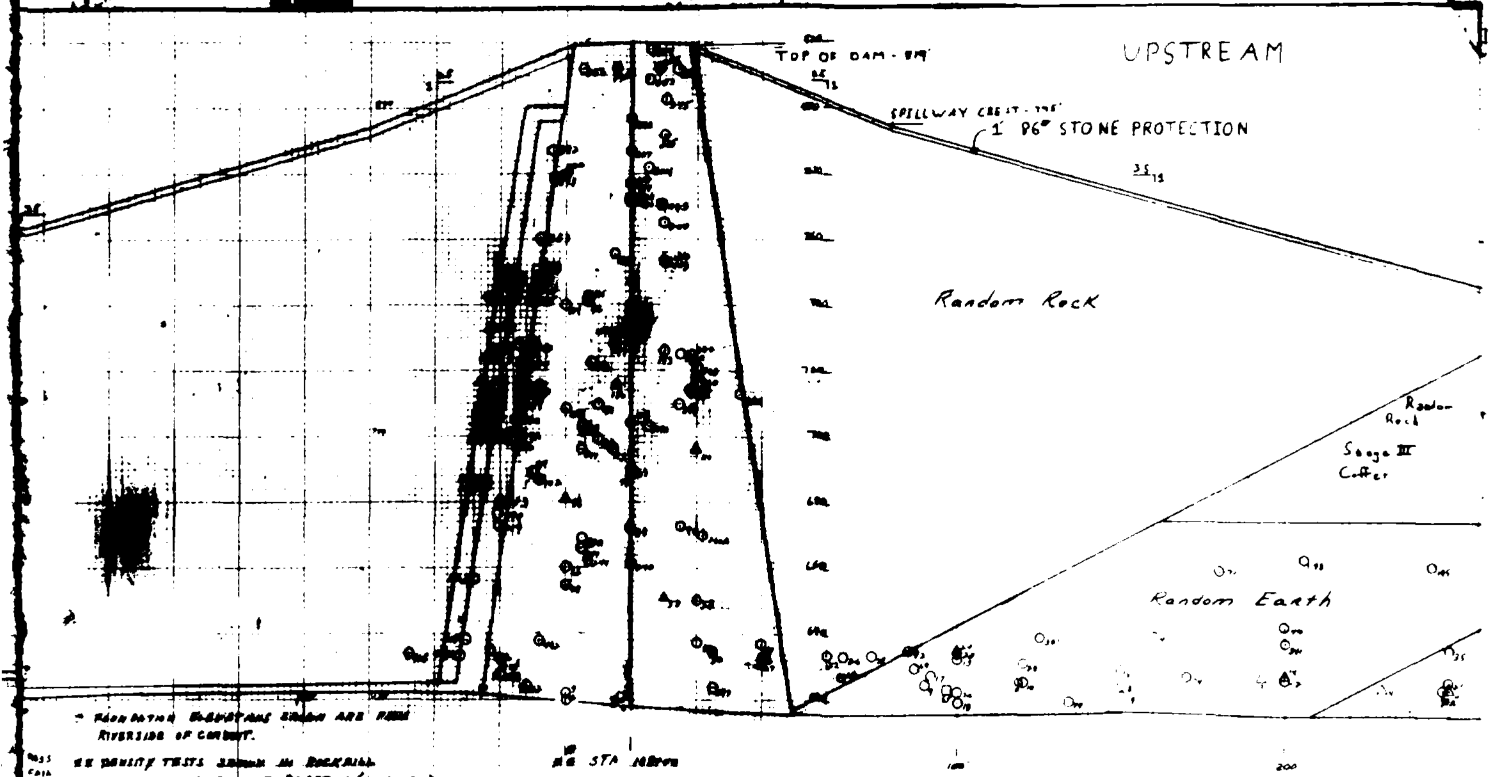
U S ARMY ENGINEER DISTRICT, LOUISVILLE
CORPS OF ENGINEERS
LOUISVILLE, KENTUCKY

DESIGNED
DRAWN TRACED
CHECKED
SUBMITTED
SCALE DATE
DRAWING NUMBER

FIELD ... TEST LOCATIONS

PLATE 93


CORPS OF ENGINEERS
DOWNSTREAM
2.5' TOP SOIL
Random Rock
-760
-740
-720
-680
-660
Downstream
Random Rock
SEASONAL POOL
1' 86" STONE PROTECTION
708'
Random Rock
Stage II Coffer
Random Rock
Stage II Coffer
Random Earth
Random Rock
Stage 1 Coffer
300'
400'
500'
600'



* FOUNDATION ELEVATIONS SHOWN ARE FROM RIVERSIDE OF CONDUIT.

** DENSITY TESTS SHOWN IN ROCKFILL SECTIONS ARE CONDUIT BACKFILL (LANDSIDE)

STA 103+00
(STA 102+00-104+00)

[illegible] DENSITY TESTS

Station	102+00	102+15	102+40	102+50	102+60	103+65	102+75
Test #	240	287	193	113A	176	279	112A
	130			301	173		108
	221			107			
	230			103C			
	294			215			

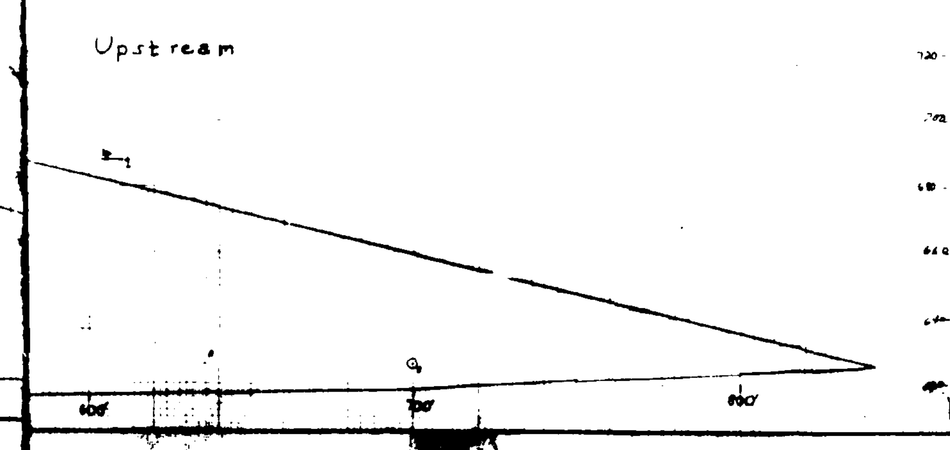
Station	102+80	102+85	102+90	103+00	103+10	103+20	103+60
Test #	141	146A	136A	118	121	278	86
	160	179		122A			
				241			
				124			
				127			
				132			
				133			
				[illegible]			

IMPERVIOUS CORE & INCLINED DRAIN TESTS

Station	102+00	102+00	102+15	102+25	102+40	102+50	102+55	102+64	102+70	102+75	102+85	102+90
Test #	239A	395	339	373	260	164	387	240	143A	150	133	136
	335	261	140	165	122	153		146		117	342	355
	227	271	493	436		149				68	406	[illegible]
	416	294	221	111		100				53		437
	110	325	438			295				143		
	256	346	334			219						
						185						

Station	103+00	103+00	103+00	103+10	103+10	103+10	103+10	103+10	103+15	103+25	103+25	103+30
Test #	112	82A	240	443	341	17	66	393	317	96	[illegible]	40
	104	71	333	180	7A	19	67	118	197	88	[illegible]	[illegible]
	107	112	353	492	9	20	74	119	69	72	18	[illegible]
	131	113	392	436	10	21	78	120	126	36	26	483
	348	257	121	425	11	22	81	99	334	30	27	14
	143	90		405	12	23	28			22	304	29
	200	102		393	14	24	29			12		[illegible]
	224	111		169	15	[illegible]	301			4		[illegible]
	245	319A		301	16	65	341			680		[illegible]
	253	345								681		[illegible]

Station	103+30	103+35	103+50	103+50	103+55	103+60	103+65	103+75	103+80	103+85	103+90	103+95
Test #	13	254	360	354	147	407	382	159	220	6	481	244
	[illegible]	76	128	8	308	718	283	135	368	195	79	[illegible]
	62	8	123	69	481	187		9		35	218	
	63	93	186	190		198		236		203	256	
	64	65A	71	254		571		260A		349		
	71	292	50			96				194		
	96					432						



REVISION	DATE	DESCRIPTION

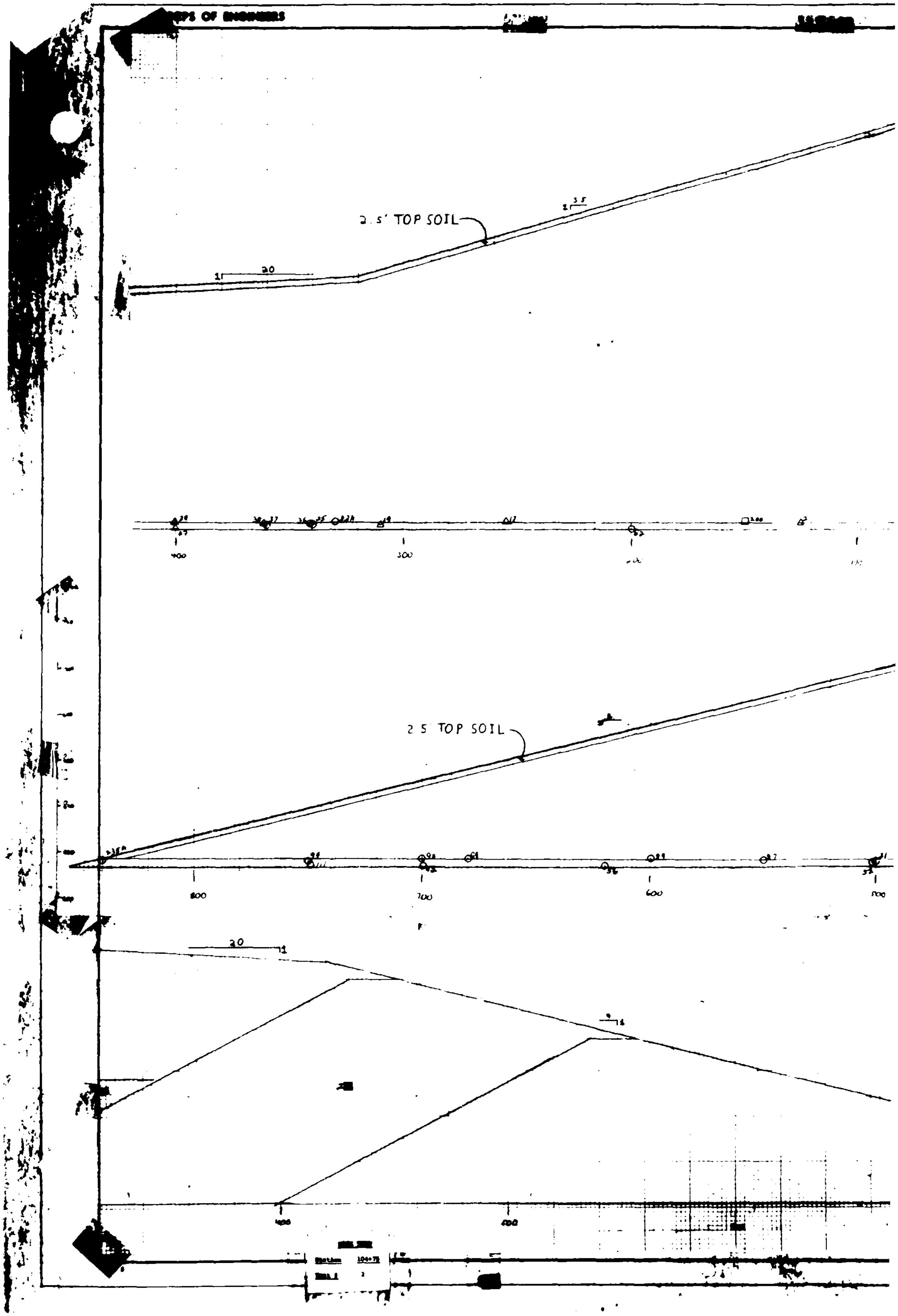
U. S. ARMY ENGINEER DISTRICT, LOUISVILLE
CORPS OF ENGINEERS
LOUISVILLE, KENTUCKY

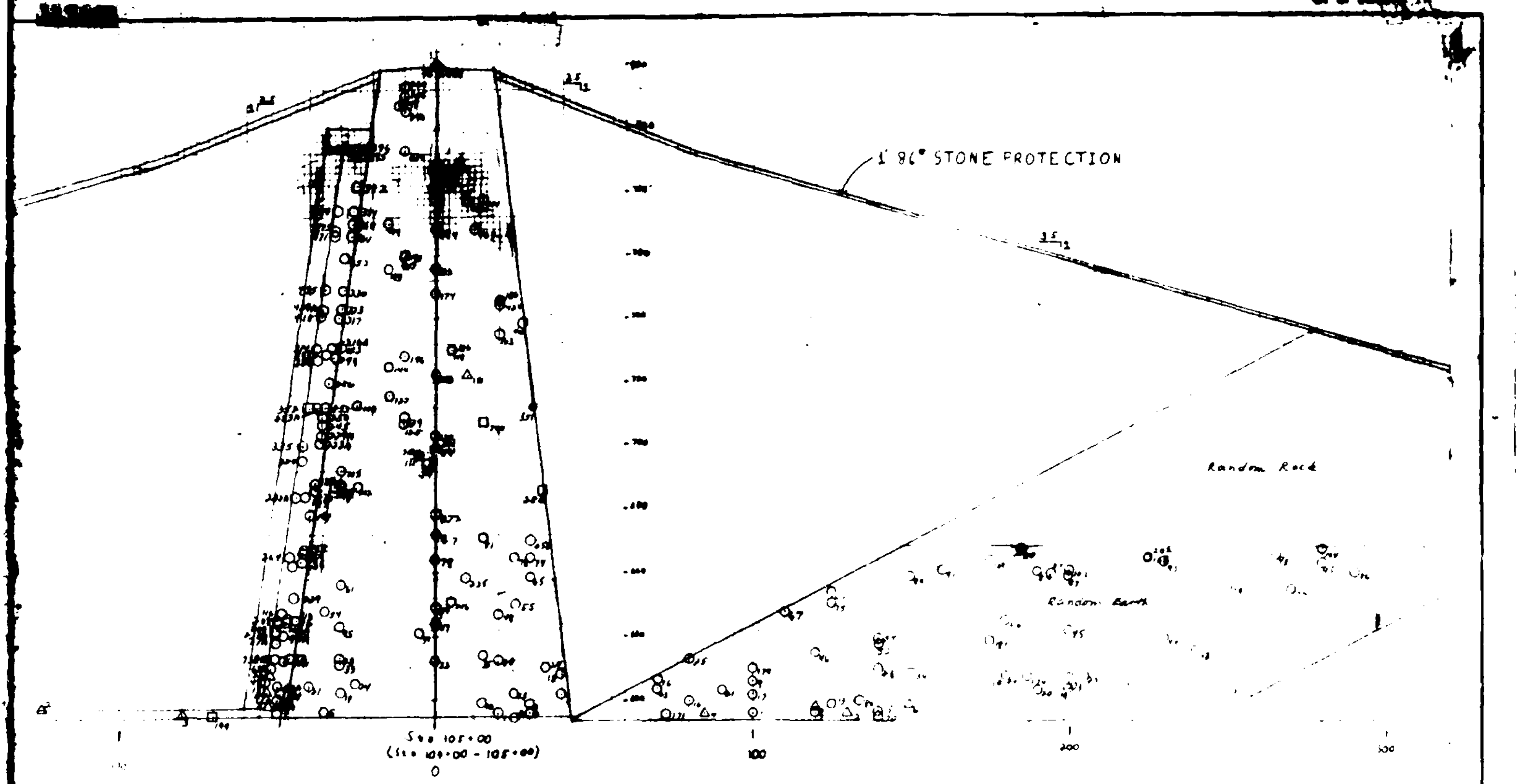
DESIGNED
DRAWN
CHECKED
SUBMITTED
SCALE

LAKE, OHIO
DAM EMBANKMENT
FIELD CONTROL TEST LOCATIONS
STATIONS 102+00-104+00

DATE
DRAWING NUMBER

PLATE 94

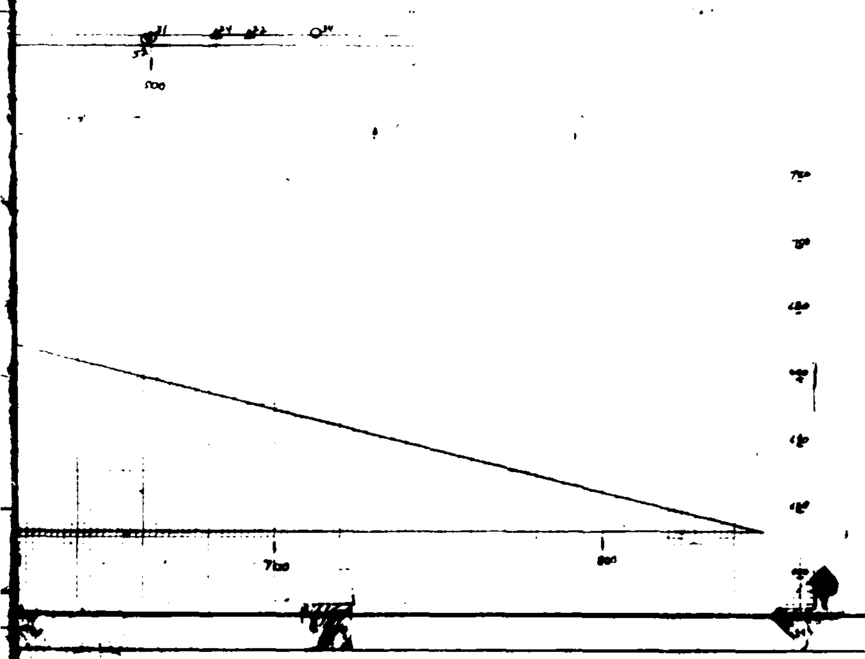

2.5' TOP SOIL
20
2.5 TOP SOIL
400
300
800
700
600
500
20



INSPECTION CORE & INCLUDED GRAIN TESTS

Station	104+00	104+00	104+00	104+05	104+10	104+20	104+25	104+25	104+35	104+45	104+5?	104+50	104+55	104+60	104+65	104+75	104+75	104+80	104+90	104+95
Test #	7	234	730	51	2	1	117	87	351	457	70	29	118	170	144	114	105	121	147	47
	21	246	158	216	6	3	88	89	80	32	16	61	778	55	486	174	188	184	25	183
	99	6	194		10		105	264	2	429A	179	32	208	24	305	424	488	474	93	218A
	110	9	245		38		170	229A	155		41	200	209	95	471	17	42	108	5	
	299	1	253		76		463	299			47	18		6A	363	91	44	20?	264	
	286	255	308		125		82				48	90		68		54	45	186		
	293	263	317		335						68	91A		153		109	81A	235		
	102	111	396								79	149				13	215A	43A		
	340	199									101	508				65	188	94		
	133	3									111									

Station	108+00	105+00	105+00	105+05	105+10	105+15	105+20	105+25	105+35	105+40	105+50	105+50	105+50	105+50	105+60	105+70	105+75	105+80	105+90
Test #	168	11	34	306	116	104	146	46	418	3	13	8	39	368	152	27?	45	173	181
	182	19	63	34		171	19	86		56	16	18	52	484	17		87	435	21
	193	20	72	382		250	35	24			17	38	70A	371	229		13	330	78
	84	23	77A			323	36	25			44	54	92		282A		35	475	27
	77	3	94				170	33			52	258	113		192		248		
	45	19	102A				314	37			56	79	220				25		
	28	141A	171A					38			67	81	223A				298		
	10	9	352								75	87	253A						
	3	22	310A								98	179	352						
	7	24	305								2	194	7						

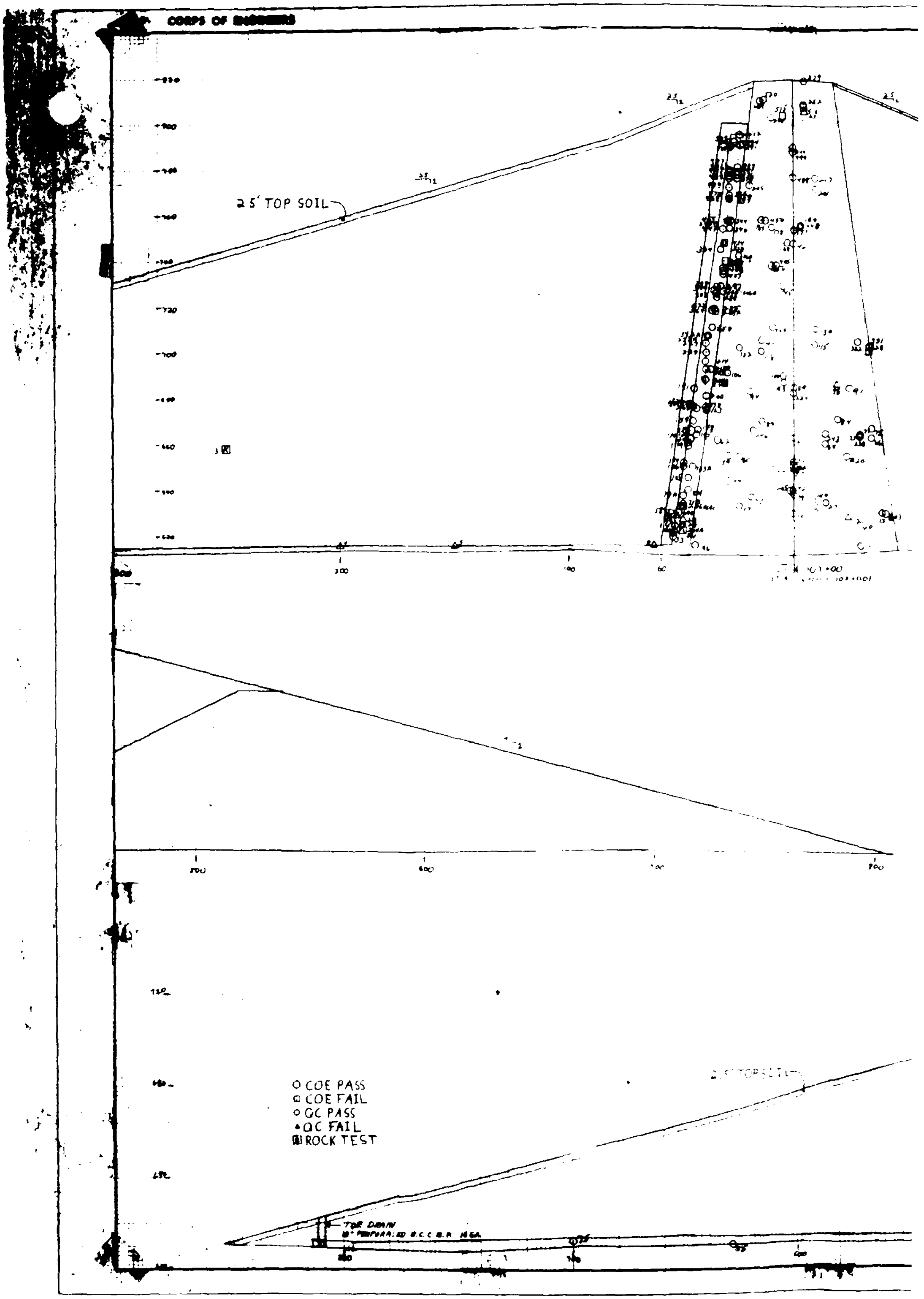


REVISION	DATE	DESCRIPTION	BY	APP'D

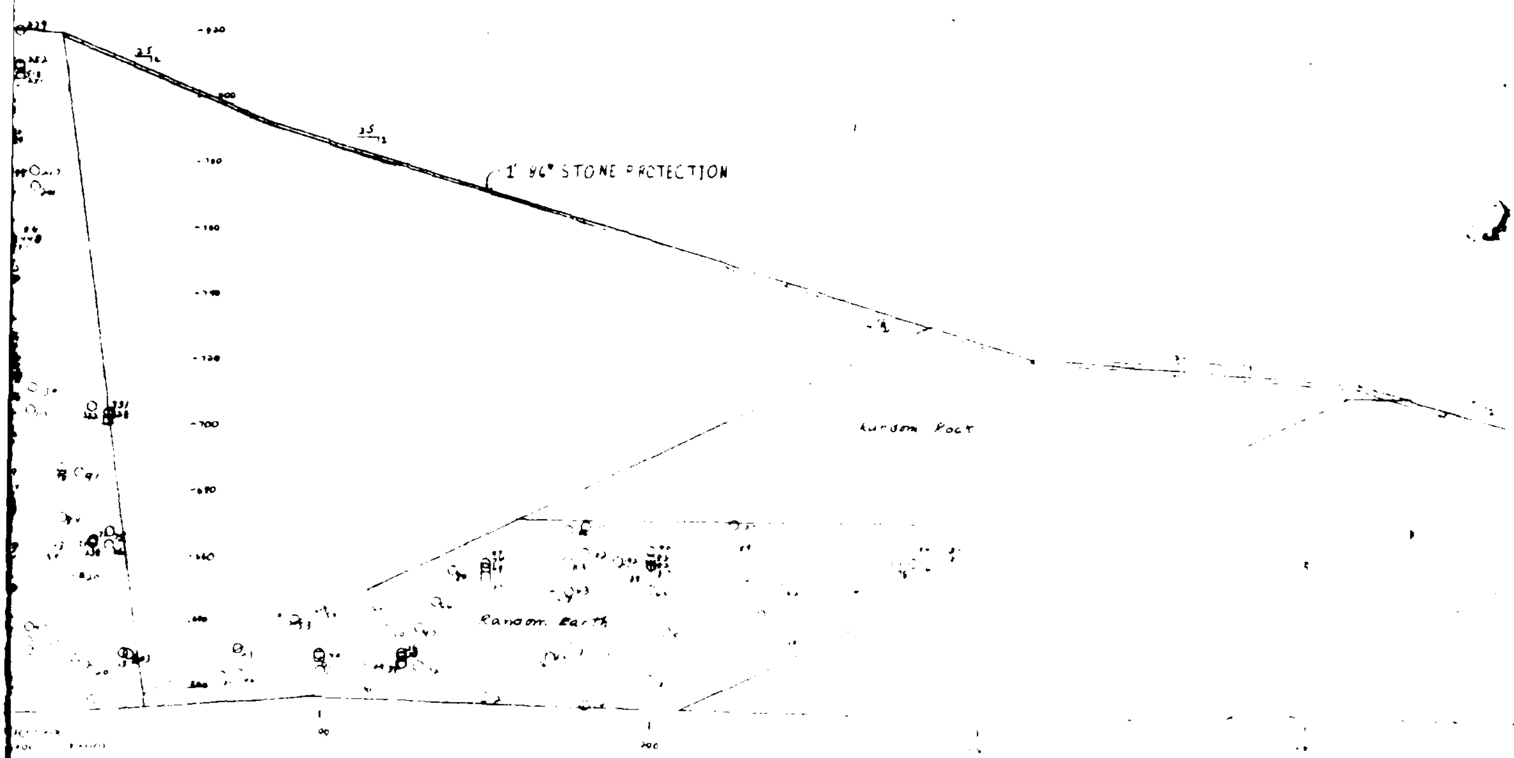
U. S. ARMY ENGINEER DISTRICT, LOUISVILLE
CORPS OF ENGINEERS
LOUISVILLE, KENTUCKY

DESIGNED
DRAWN
TRACED
CHECKED
SUBMITTED
SCALE
DATE
DRAWING NUMBER

EAST FORK LAKE, OHIO
DAM EMBANKMENT
FIELD CONTROL TEST LOCATIONS
STATIONS 104+00 - 106+00

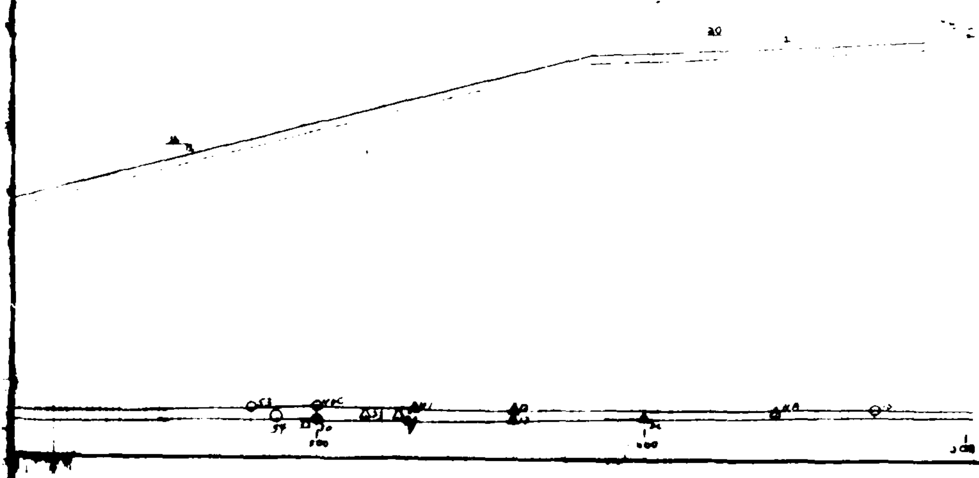


CORPS OF ENGINEERS
2.5' TOP SOIL
O COE PASS
COE FAIL
O GC PASS
QC FAIL
ROCK TEST
TOE DRAIN



Station	106+00	106+50	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Test #	191	12	240	84	146	1?	12	178
	[illegible]	[illegible]	538	69	168		18	[illegible]
	[illegible]	[illegible]	[illegible]	19			499	[illegible]
	346	66A	[illegible]	4			174	[illegible]
	479	58	[illegible]	[illegible]				[illegible]
	468	12	72	[illegible]				[illegible]
	447	16	64	[illegible]				[illegible]
	307	[illegible]	59					344
	[illegible]	251	[illegible]					366
	[illegible]	244	[illegible]					

Station	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Test #	252	80	148	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	488
	[illegible]	63	303	105	284	[illegible]	94	[illegible]	[illegible]	[illegible]
	75	65	344	497	[illegible]	[illegible]	168	[illegible]	[illegible]	
	44	62	496						[illegible]	[illegible]
	42	55	381						[illegible]	
	20	203	383							
	15	11								
	107	55								
	85	129								
	82	134								



ROCK TESTS

Station	[illegible]	[illegible]
Test #	12	40
	10	

REVISION	DATE	DESCRIPTION	BY	APP'D

U. S. ARMY ENGINEER DISTRICT, LOUISVILLE
CORPS OF ENGINEERS
LOUISVILLE, KENTUCKY

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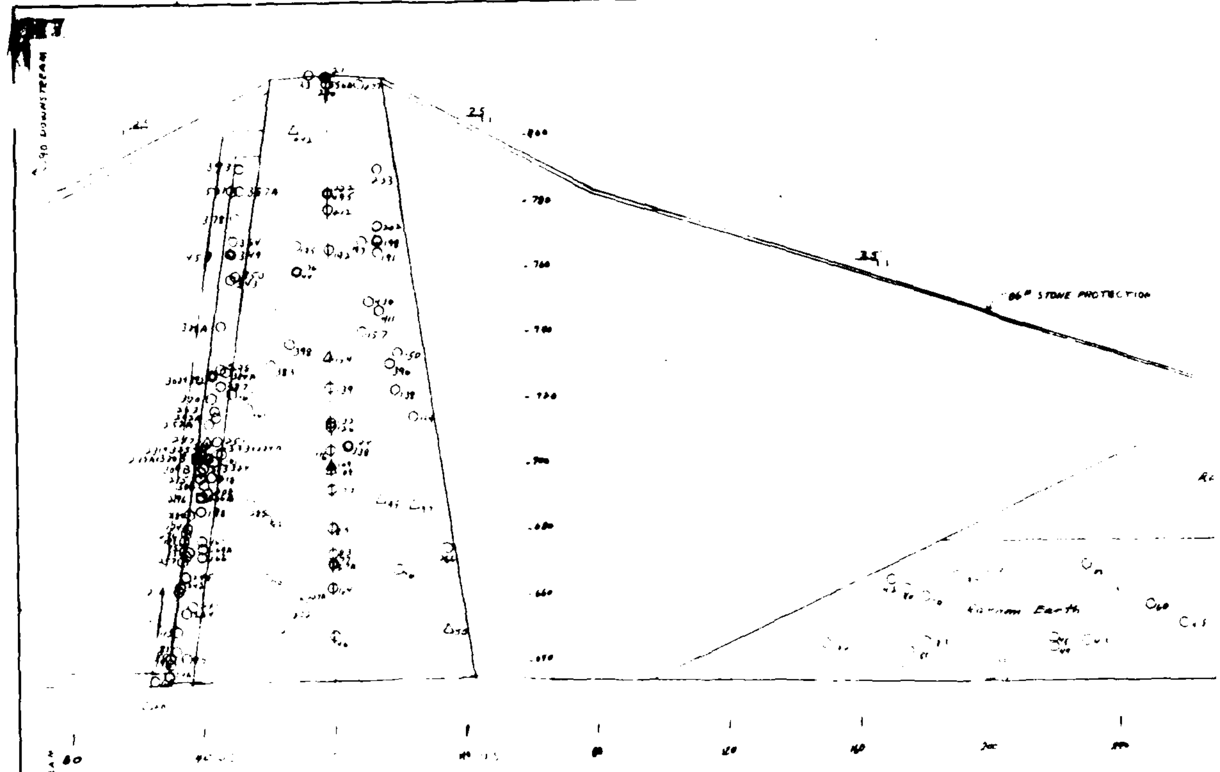
CHECKED
SUBMITTED
SCALE

[illegible] OHIO
[illegible] EMBANKMENT
FIELD [illegible] TEST LOCATIONS
STATIONS [illegible] - 108+00

DATE
DRAWING NUMBER

PLATE 16

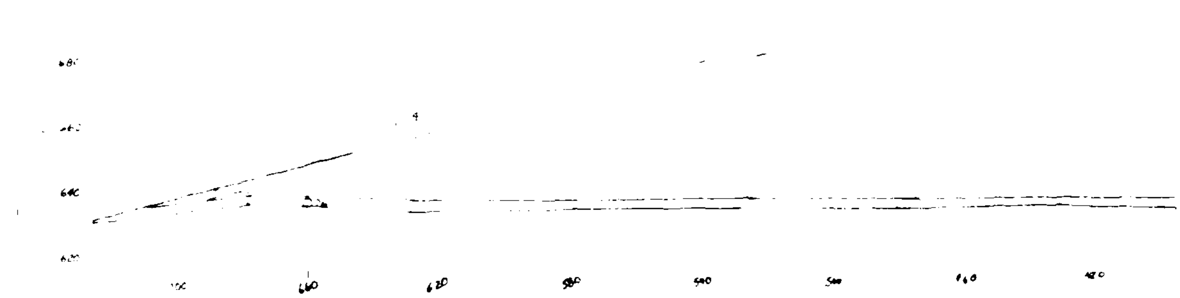
CORPS OF ENGINEERS



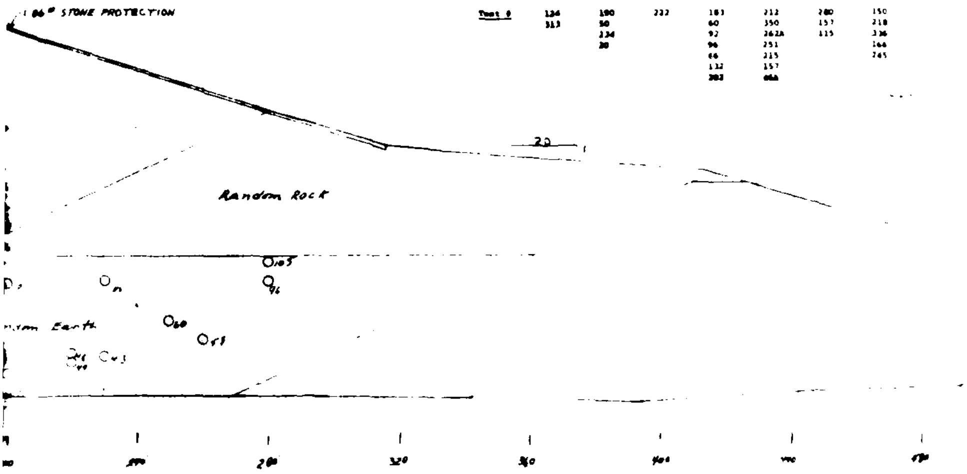
RIGHT ABUTMENT SAND FILTER BLANKET TESTS

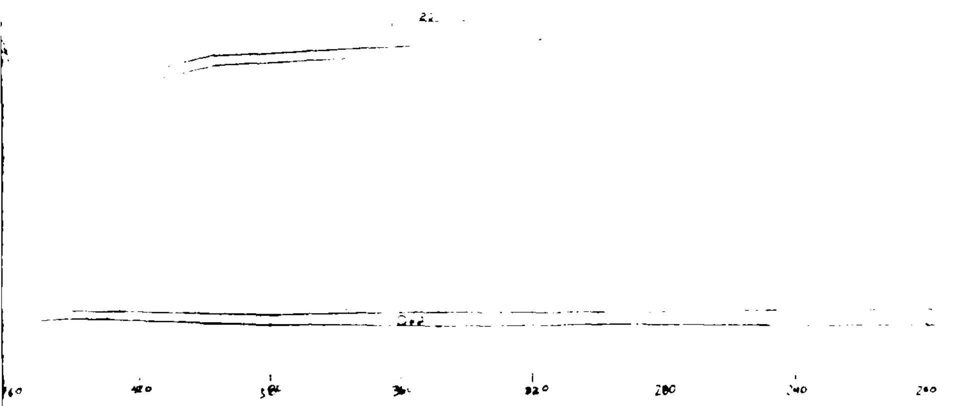
Station	100+00	100+10	100+25	100+50	109+00	109+25	109+30
Test #	16 93	68	67	59 618 66	478 151	85	164 143

Station	109+50	109+55	109+75	109+80	190+85	109+90
Test #	107 253A 144 160	301	225 108A 110 201	269	172	175 185 188 19A



Station	100+00	100+00	100+00	100+05	100+20	100+25	[illegible]
Test #	33	361	211	[illegible]	182	[illegible]	280
	49	191	81		266	198	43
	58	197	80		[illegible]	138	92
	100	233	79		181	320A	338
	101	378	74A		390	224	[illegible]
	105	263	60		324	95	
	52	239A			309B	[illegible]	
	76	333					
	97	181					
	103	169A					
Station	**100+35**	**100+40**	**100+45**	**100+50**	**100+50**	**100+60**	**100+70**
Test #	124	190	222	183	212	280	150
	313	50		60	350	157	218
		234		92	262A	115	336
		30		96	251		166
				66	215		245
				132	157		
				302	66A		





NEER DISTRICT LOUISVILLE
OF ENGINEERS

DRAWING NUMBER

PLATE 97

CORPS OF ENGINEERS

RIGHT ABUTMENT SAND FILTER BLANKET TESTS

Station	110+00	110+20	110+50	110+55	110+65	110+75	110+80	110+85	110+90	[illegible]	111+00	110+[illegible]
Test No.	251 265 142 152 159 184 203 205 207	167	186 195 326 341 344 312A 249 345A	197	199 228	202 234 241	211 212 304	255 371B 271 323A	217	291A	329 339 226	266

Station	111+2[illegible]	111+30	111+35	111+40	111+50	111+70	111+90	112+00	112+[illegible]	[illegible]	112+85
Test No.	268 415 425	270 30[illegible] 404A	309 329	428	391A 396 400 302 311 312 323	444	363	132 136 466 473 154 156	482 170 494 38C	188	502A 386

820

800

780

760

740

720

700

340

350

IMPERVIOUS CORE & INCLINED DRAIN TESTS

Station	110+00	110+00	110+15	110+25	110+40	110+45	110+50	110+53	110+63
Test #	209 207 205 177 358	151 172 449 476 183 207 490 247 464 433 380 379	161	169 318A 413A 189	86 175	389 285	179 507 214 236 355 351 46C 369B	440	462

Station	110+95	111+00	111+05	111+10	111+20	111+40	111+50	111+75	111+80
Test #	203 358 467 290	238 389 348 465 458 401 293 176 276B 284	514	456 623	258 374	362 361	199 223 39C 342 339 446	21[illegible] 155 326 632	206

Station	112+50	112+85	112+90	112+94	113+00	113+20	113+25	113+30	113+50
Test #	171 443	503 232	250	511	262	267	519	517	553 274 22

ROCK TEST

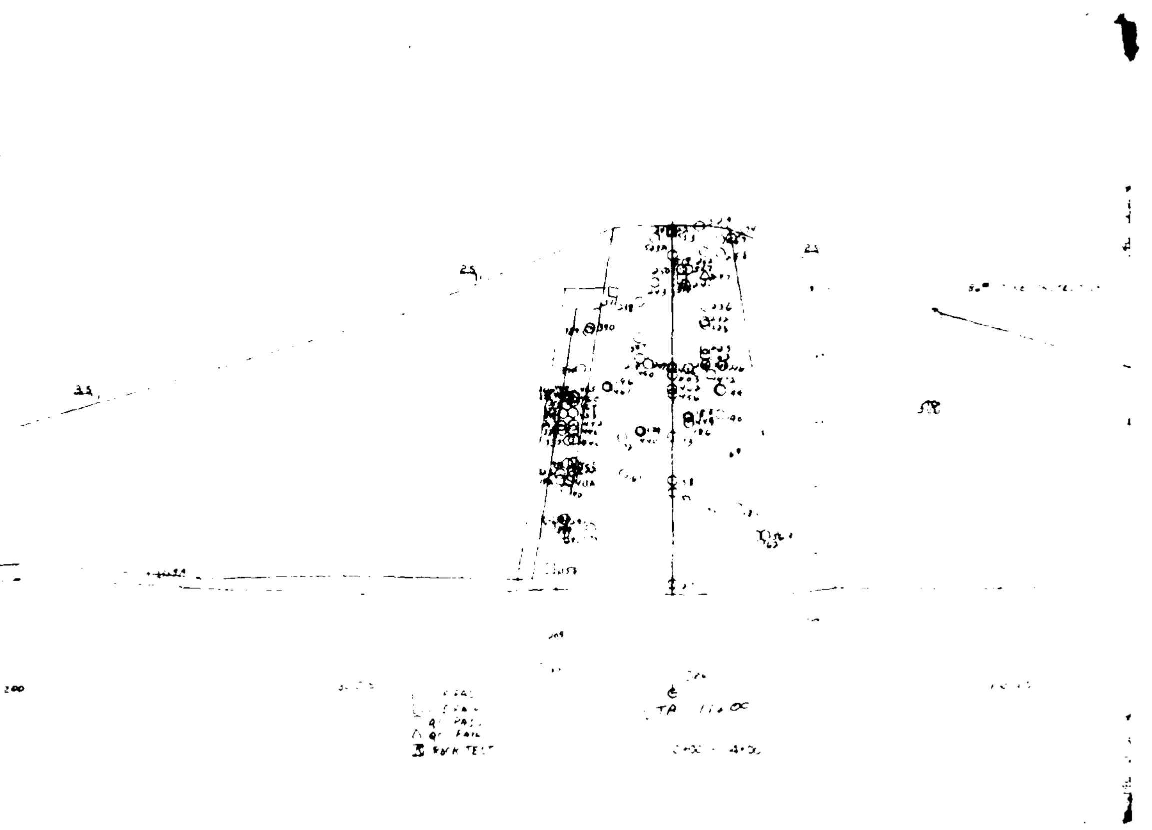
Station	111+00
Test #	50

35

300

300

U S ARMY



110+95	111+00	110+20
291A	129	266
	339	
	226	

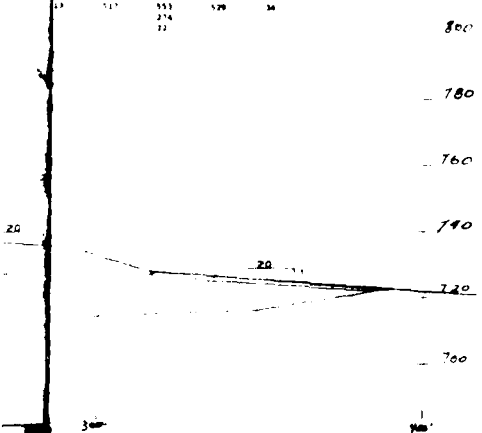
111+90	112+95
188	502A
	186

110+82
523A
337
445
264

110+50	110+53	110+63	110+75	110+82	110+90
[illegible]	440	462	472	523A	127
			359A	337	417
			354	445	
				264	

111+50	111+75	111+80	111+90	112+00	112+30
[illegible]	[illegible]	206	461	158	228
	[illegible]		186	190	241
	326		196	219	452
	452			360	
				469	

113+25	113+30	113+50	113+55	114+00
[illegible]	517	553	529	34
		274		
		32		



REVISION	DATE	DESCRIPTION	BY	APPD

U S ARMY ENGINEER DISTRICT LOUISVILLE
CORPS OF ENGINEERS
LOUISVILLE KENTUCKY

DESIGNED
DRAWN TRACED
CHECKED
SUBMITTED
SCALE DATE
DRAWING NUMBER

PLATE 91

Corps of Engineers Accept[illegible]

Material (ZONE)	Number of tests	Dry Density High	Low	Aveg	Design	Percent Compaction High	Low	Aveg
Impervious*	232	130.5	110.0	121.6	130.0	100 +	93.5	99.0
Random**	45	126.7	111.2	121.3	125.0	98.8	92.3	9[illegible].
Pervious***	260	120.9	108.7	115.5	120.0	89.7	41.1	85.3

* Of the 232 tests run on impervious material, 40 tests failed to meet optimum wa[illegible]
Of the tests that failed, 39 were reworked and 4 were retested with ac[illegible]
desired compaction. All of these were reworked and 7 were retested wit[illegible]

** Of the 45 tests run on random material, 5 tests failed to meet optimum wat[illegible]
Of the tests that failed, 5 were reworked but none were retested. Of th[illegible]
[illegible] were reworked and 2 were retested with acceptable results.

*** [illegible] tests run on pervious material, 114 failed to meet the desired
[illegible] results. No moisture control was specified

Contractor Field Compactio[illegible]

Material (ZONE)	Number of Tests	Dry Density High	Low	Aveg	Design	Percent Compaction High	Low	Aveg
Impervious *	[illegible]	[illegible]	[illegible]	124.2	130.0	100+	94.4	100 +
Random **	[illegible]	[illegible]	[illegible].8	123.5	125.0	100 +	96.3	100+
Pervious ***	[illegible]	[illegible]	111.[illegible]	[illegible]	120.0	100 +	42.8	83.4

* Of the [illegible] tests run on impervious material, 133 tests failed to me[illegible]
optimum. Of the tests that failed 132 were reworked and 21 were re[illegible]
[illegible] compaction. These 11 areas were reworked and[illegible]

** Of the 45 tests run on random material, 14 failed to meet optimum wa[illegible]
[illegible], 14 were reworked and 1 was retested with a[illegible]
[illegible] of these areas were reworked and retested with[illegible]

*** Of [illegible] pervious material, 242 failed to meet the
[illegible] results. No moisture control was specified.

[illegible] on the impervious and random materials, [illegible]
[illegible] control specified.
2. [illegible] tests for high and low values and indicate [illegible]

...s ACCEPTANCE TESTS - Harsha Dam

...ction ① ③		Water Content ③				Deviation from Op[illegible] ③			
Aveg	Desired	High	Low	Aveg	Design	High	Low	A[illegible]	[illegible]
99.0	95.0	16.0	8.5	11.5	15.0	+1.7	-2.3	-0.7	[illegible]
9[redacted].	95.0	13.6	8.8	10.3	15.0	+1.1	-2.1	-1.2	[illegible]
85.3	80.0	N/A ②	N/A ②	N/A ②	N/A ②	N/A ②	N/A ②	N/A ②	N/A ②

...imum water content (14 tests were too wet of optimum, 26 were too dry of [illegible]
...with acceptable results. Of the impervious material tested, 16 were below the [illegible]
...ted with acceptable results.
...mum water content (1 test was too wet of optimum, 4 tests were too dry of optimum).
... Of the random material tested, 11 areas were below the desired compaction [illegible]
...ults.
...desired compaction; 73 areas were reworked and 50 areas were [illegible]

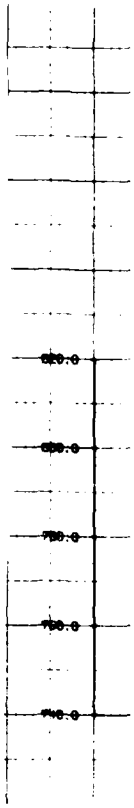
...ompaction Tests - Harsha Dam

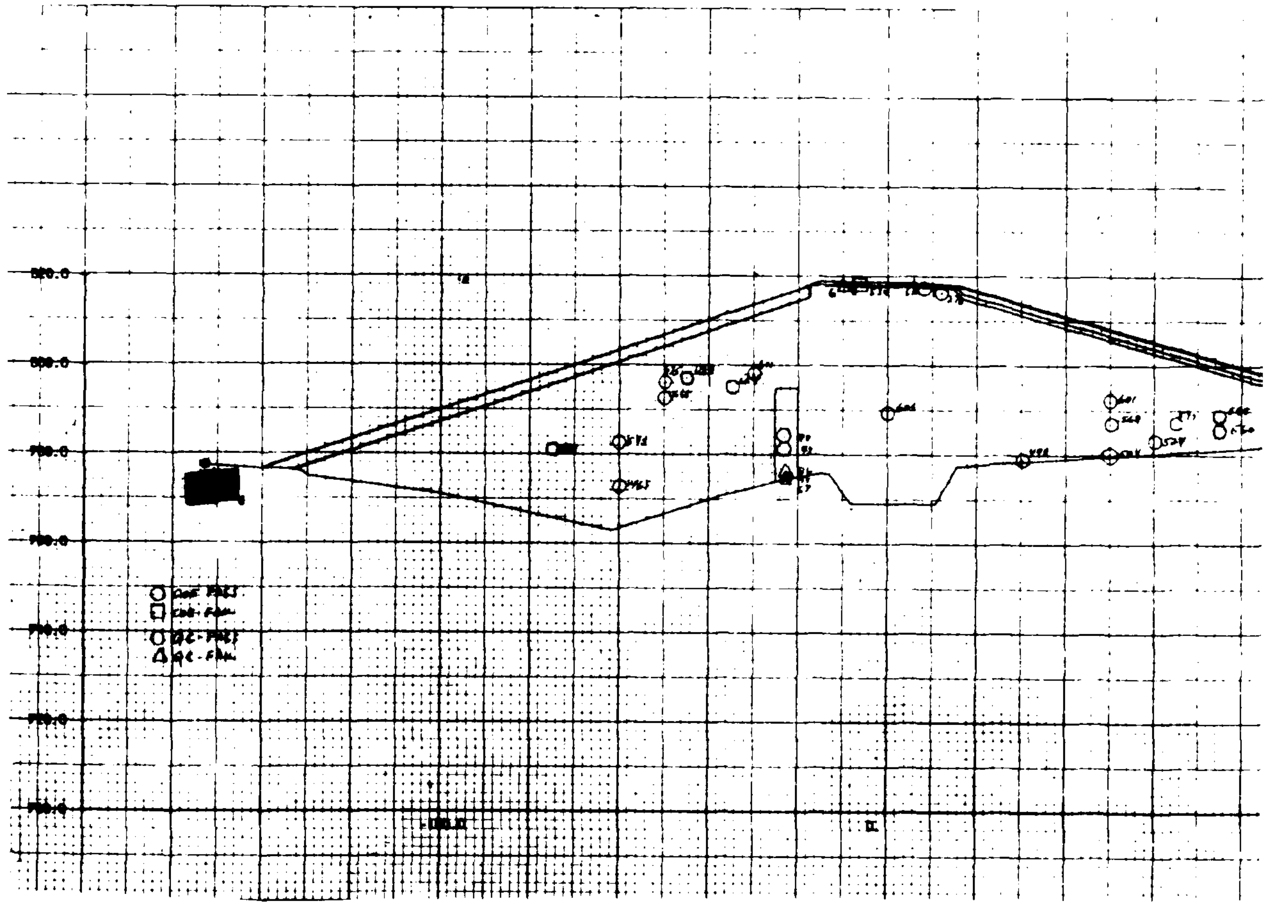
...mpaction ① ③		Water Content ③				Deviation from [illegible]			
Aveg	Desired	High	Low	Aveg	Design	High	Low	[illegible]	[illegible]
100+	95.0	.7.5	7.6	11.5	15.0	+1.5	-2.9	[illegible]	[illegible]
100+	95.0	15.4	9.8	11.6	.5.0	+1.2	-2.[illegible]	[illegible]	[illegible]
83.4	80.0	N/A ②	N/A ②	N/A ②	N/A ②	N/A ②	N/A ②	N/A ②	N/A

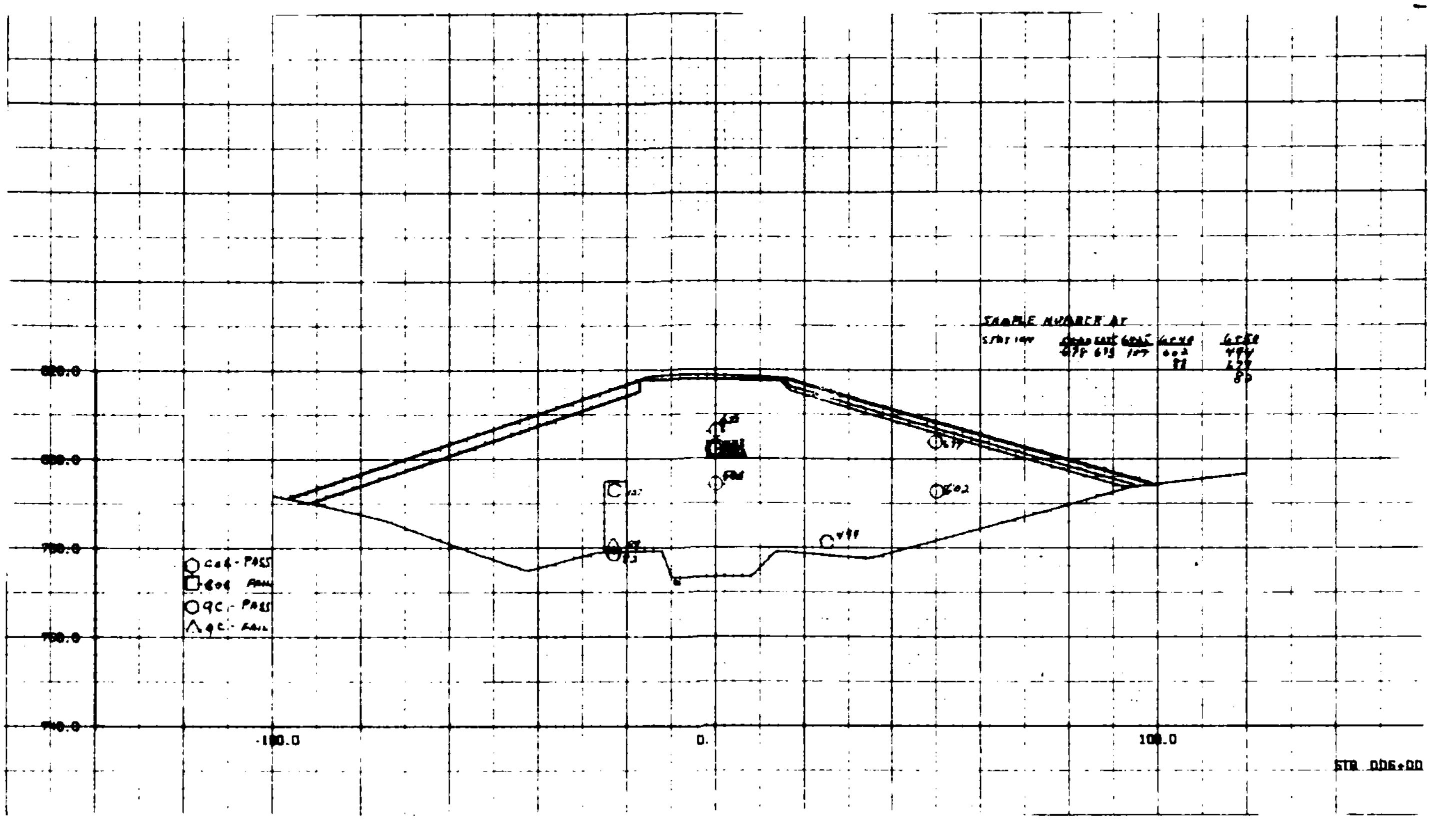
...l to meet optimum water content (32 were too wet of optimum [illegible]
...were retested with acceptable results. Of the impervious m[illegible]
...e and 3 were retested with acceptable results.
...mum water content. (1 was too wet of optimum and 13 [illegible]
...with acceptable results. Of the random material tested [illegible]
...ed with acceptable results.
...eet the desired compaction. 165 areas were reworked and [illegible]

...erials, relative density test used on the pervious material.

...licate results of acceptable tests and retests for [illegible]



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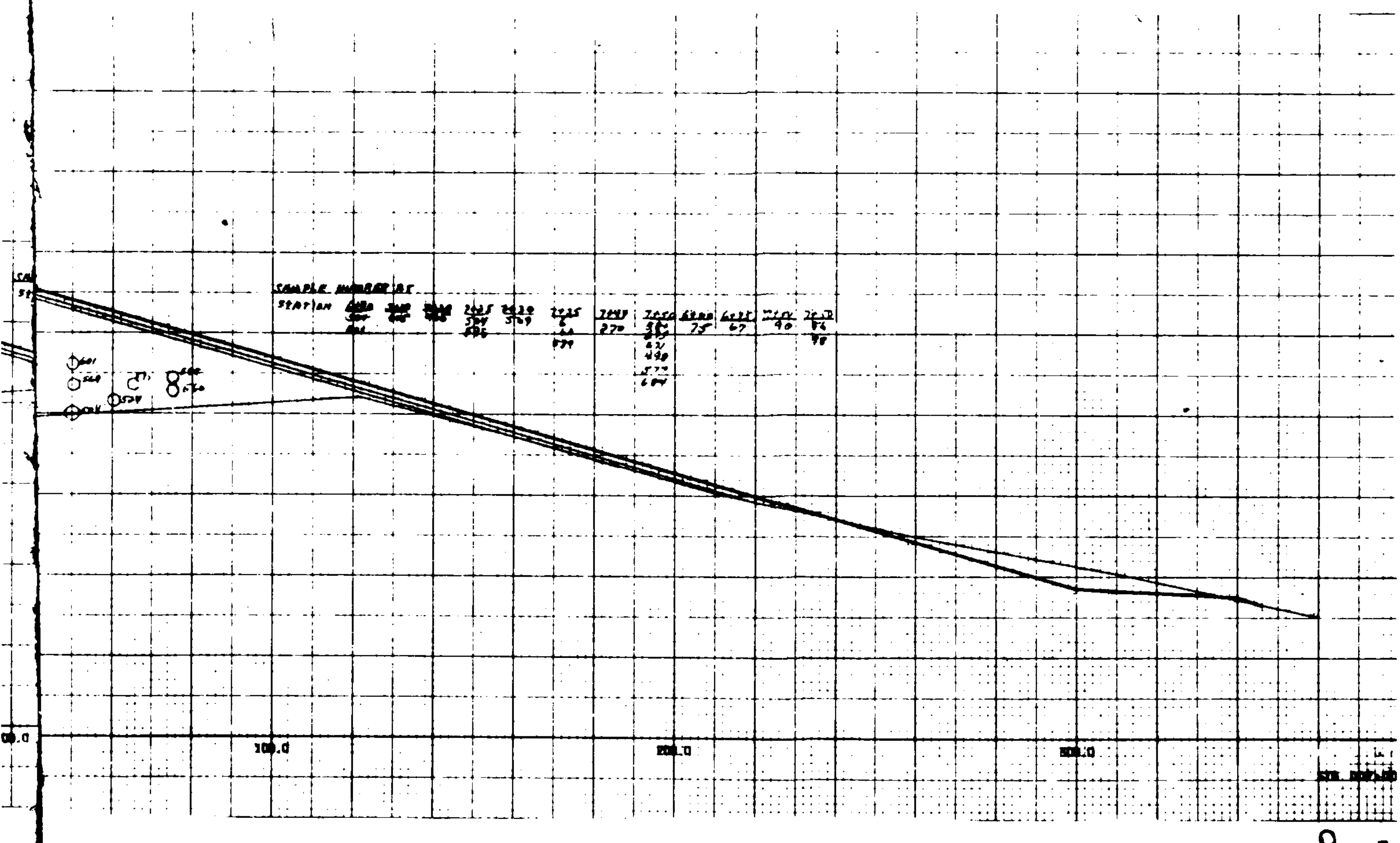
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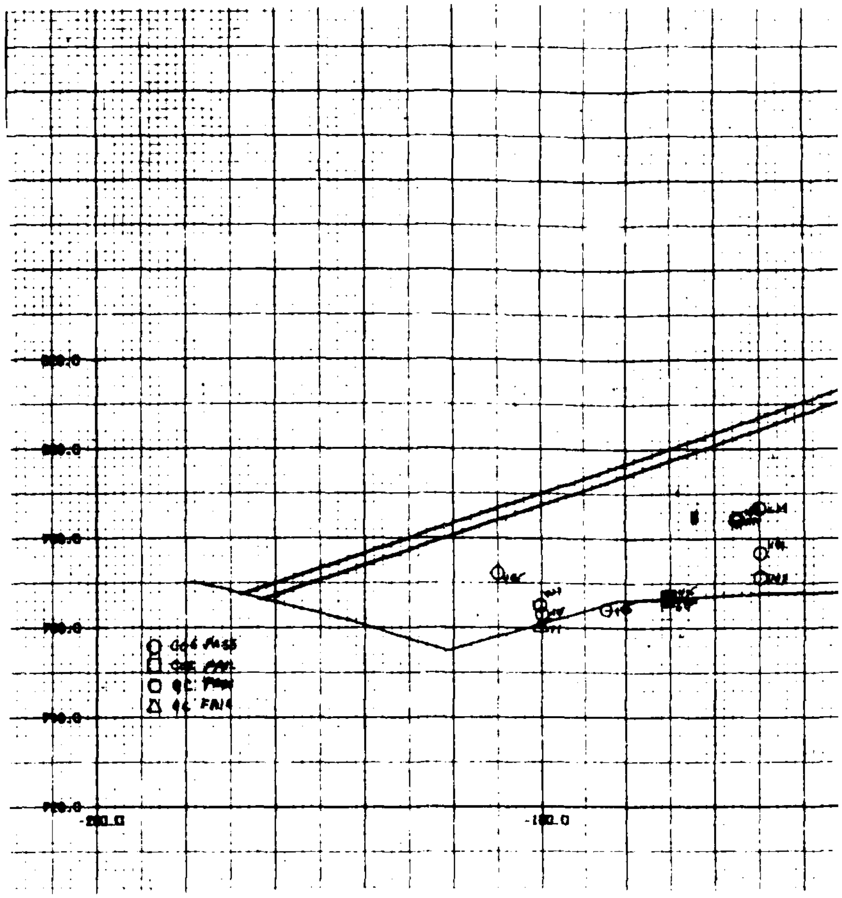
PLATE 100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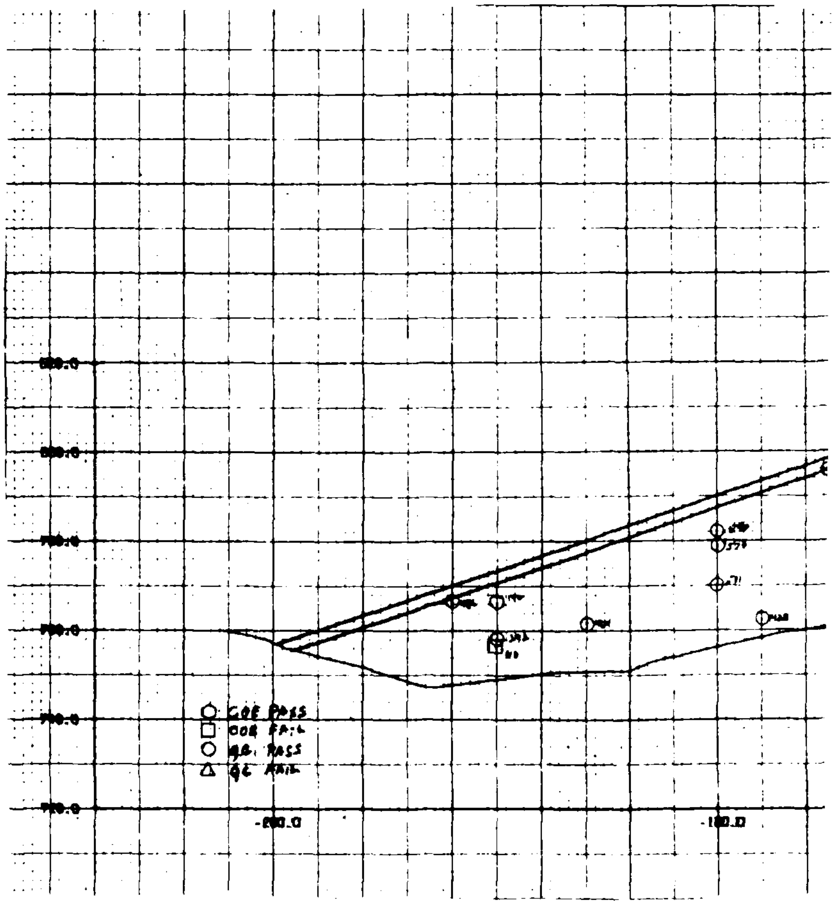
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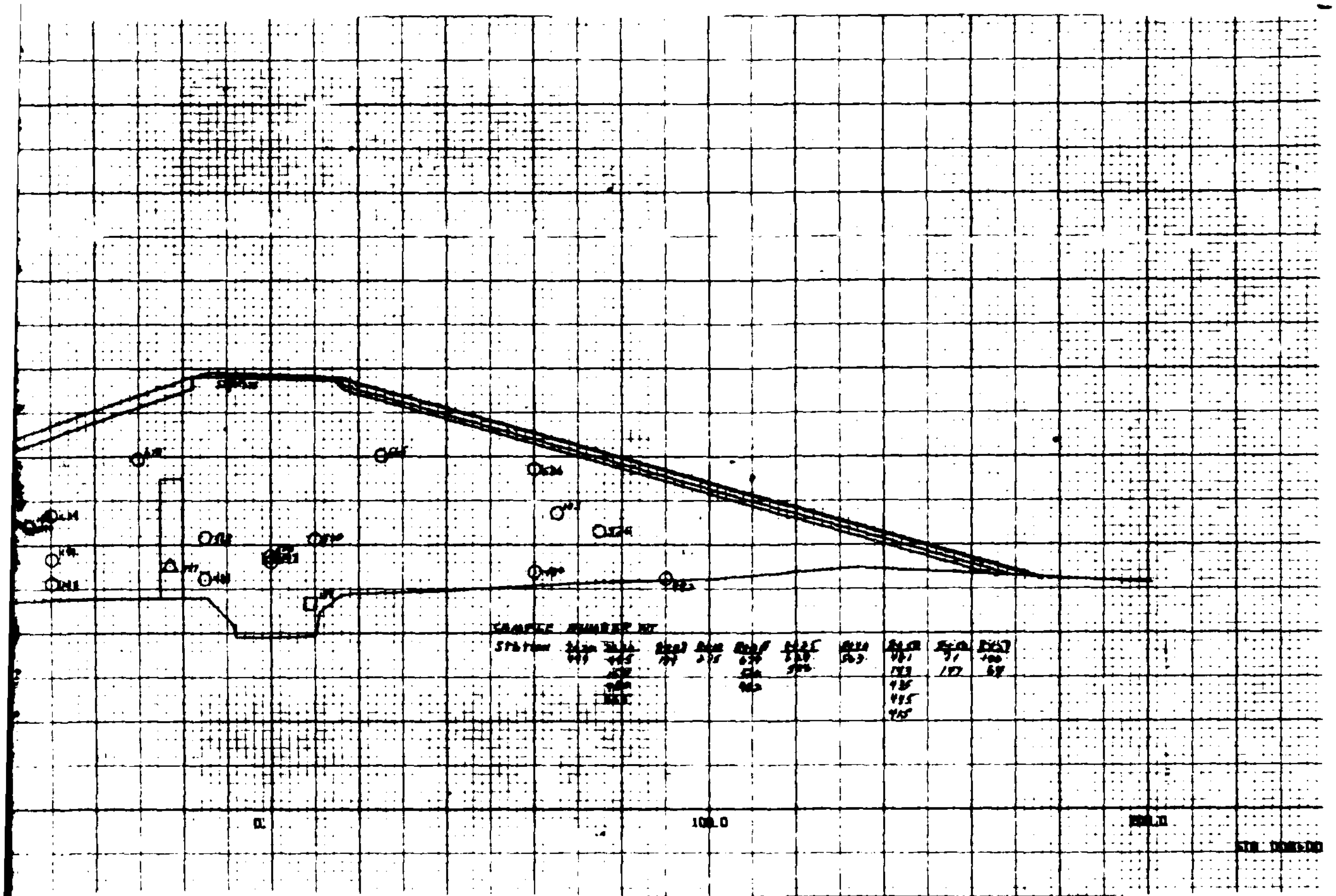
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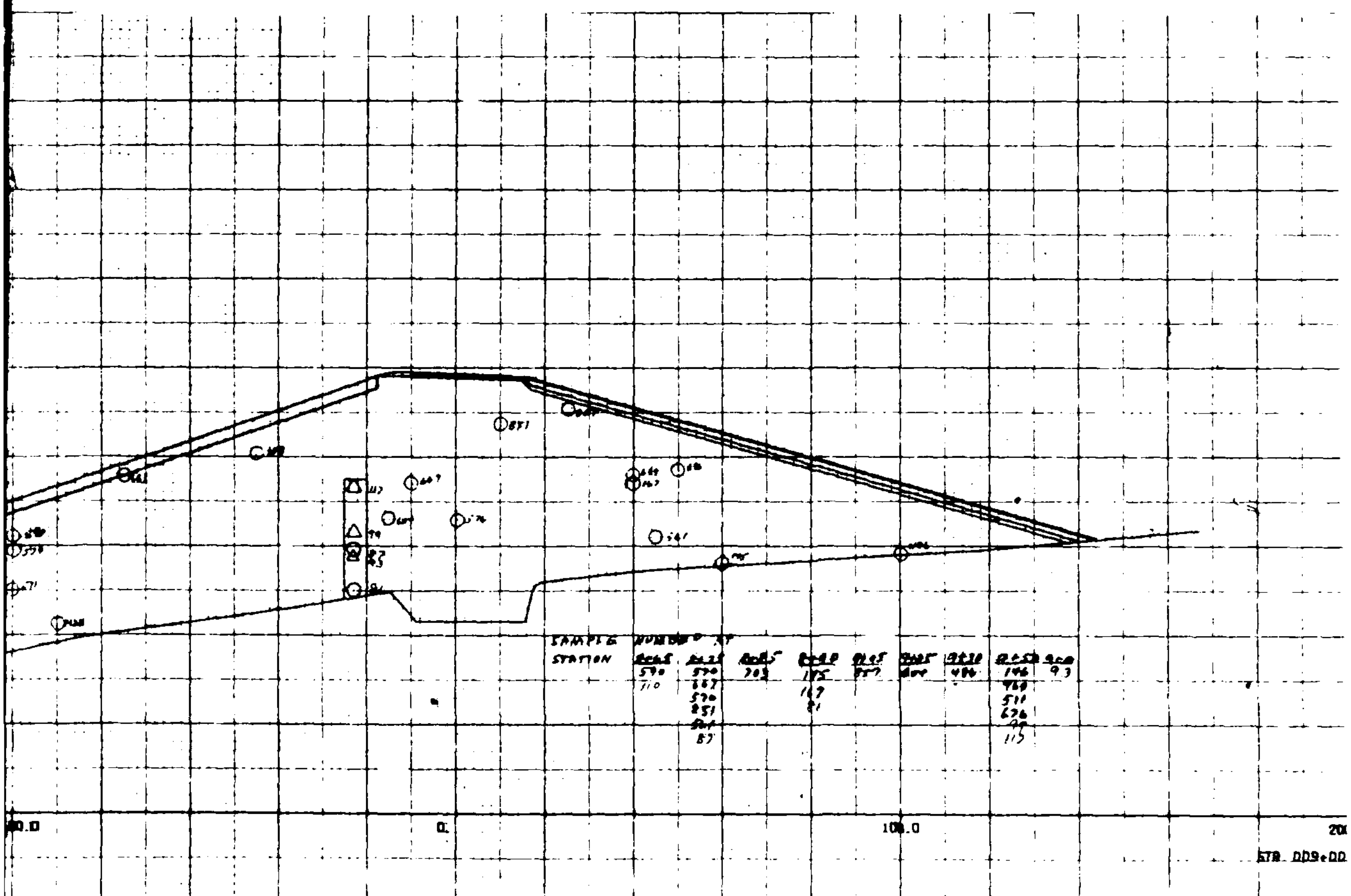
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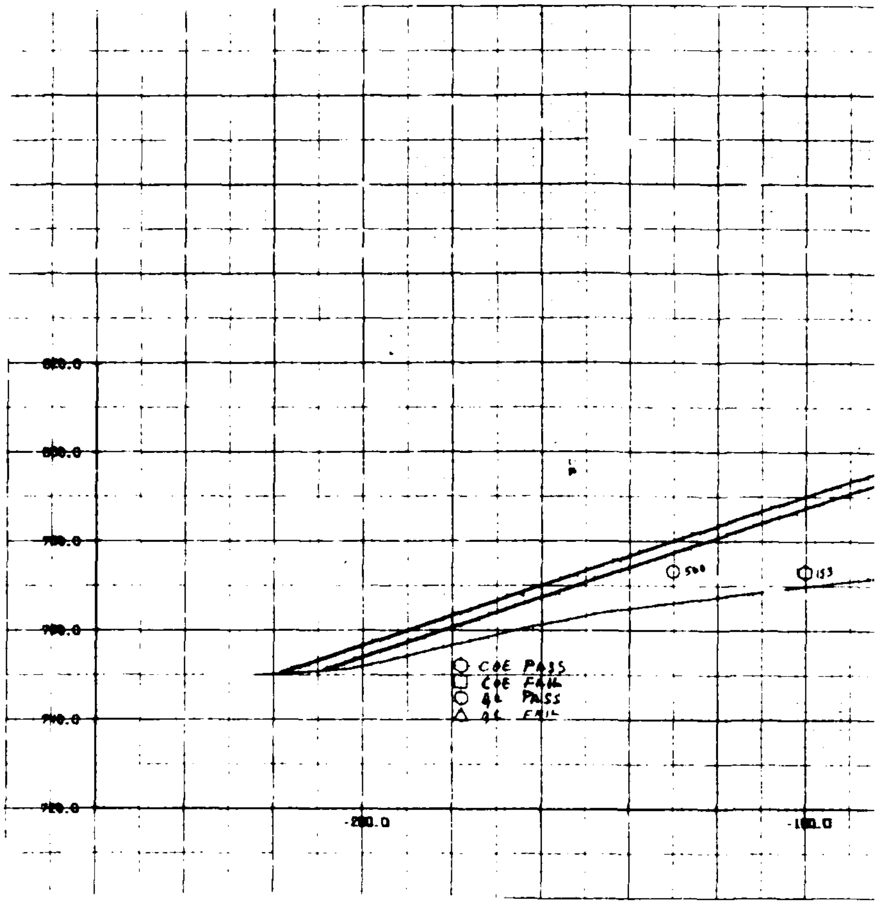
PLATE 101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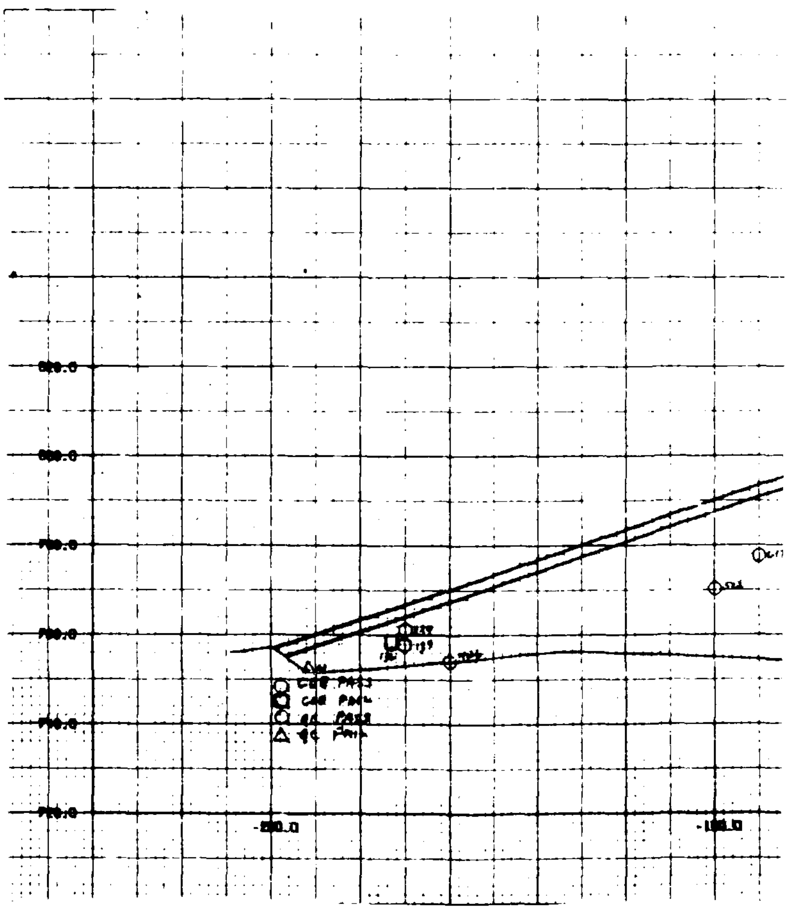
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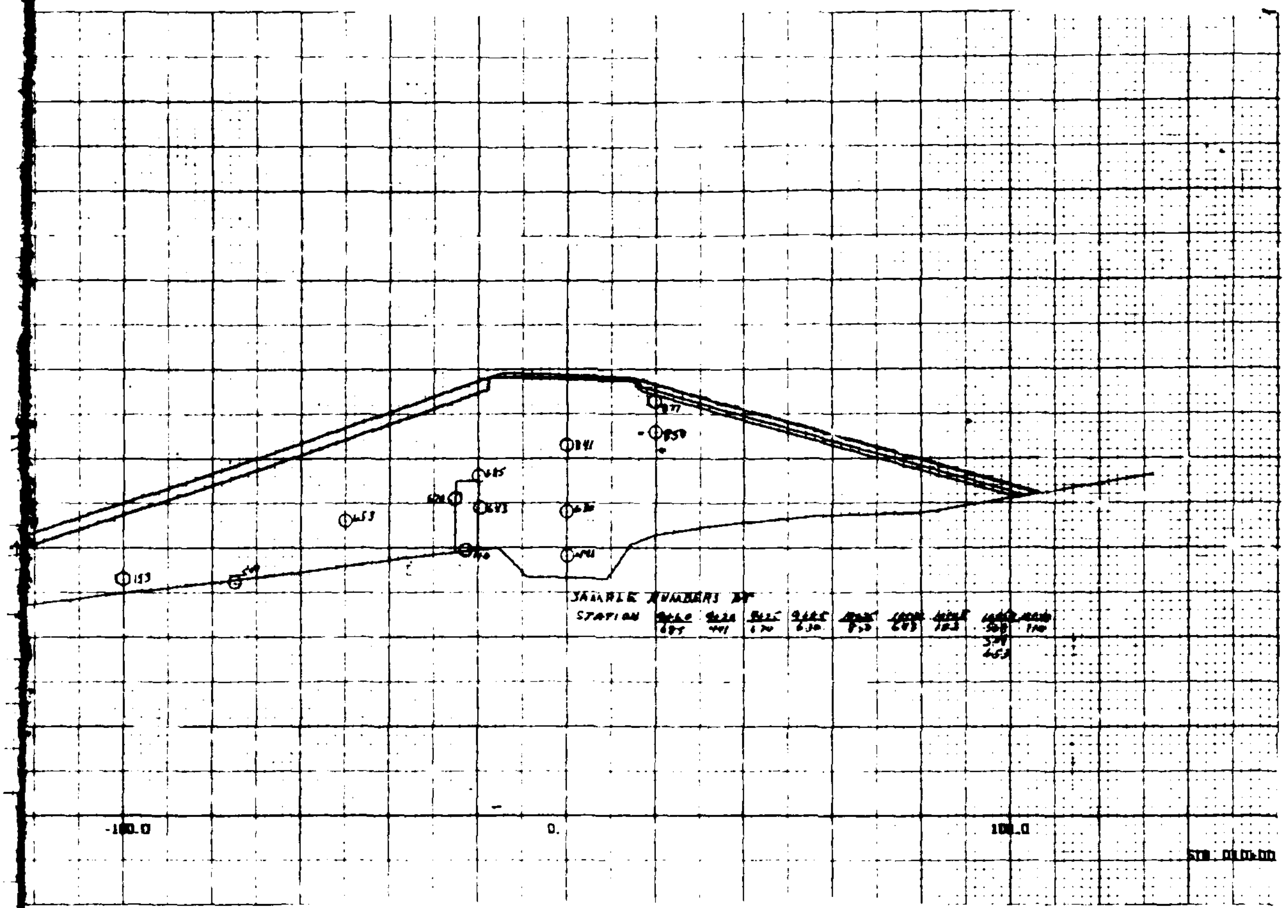


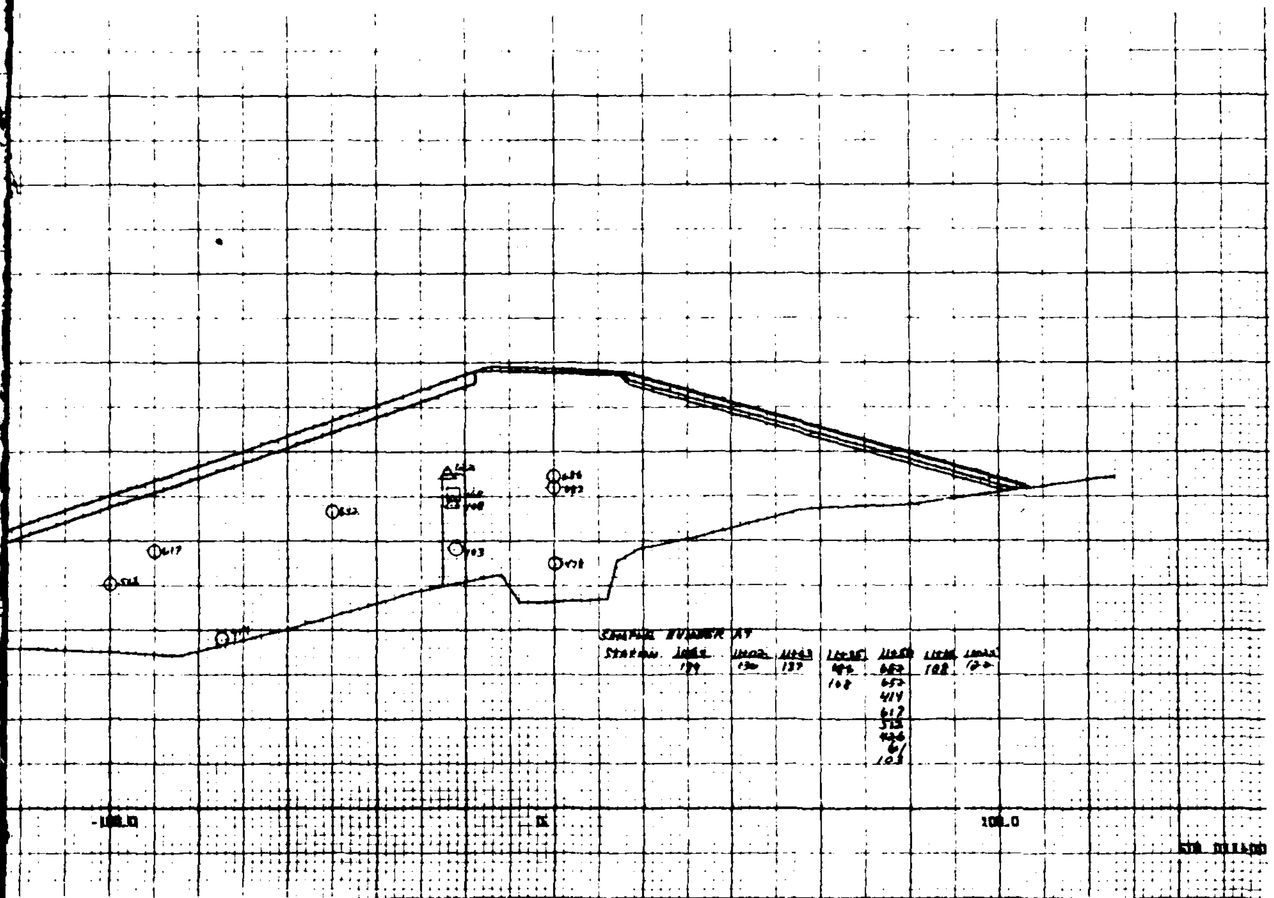
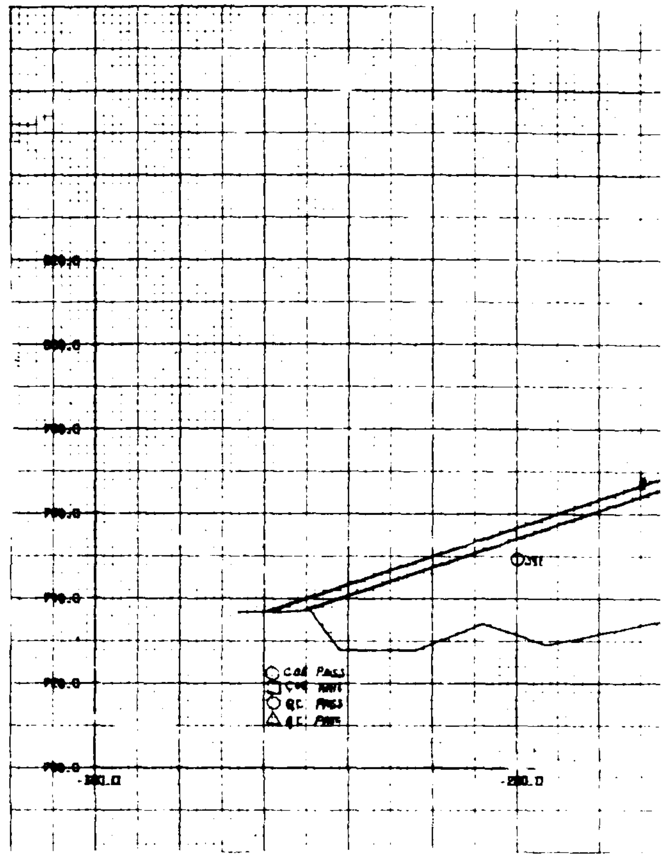
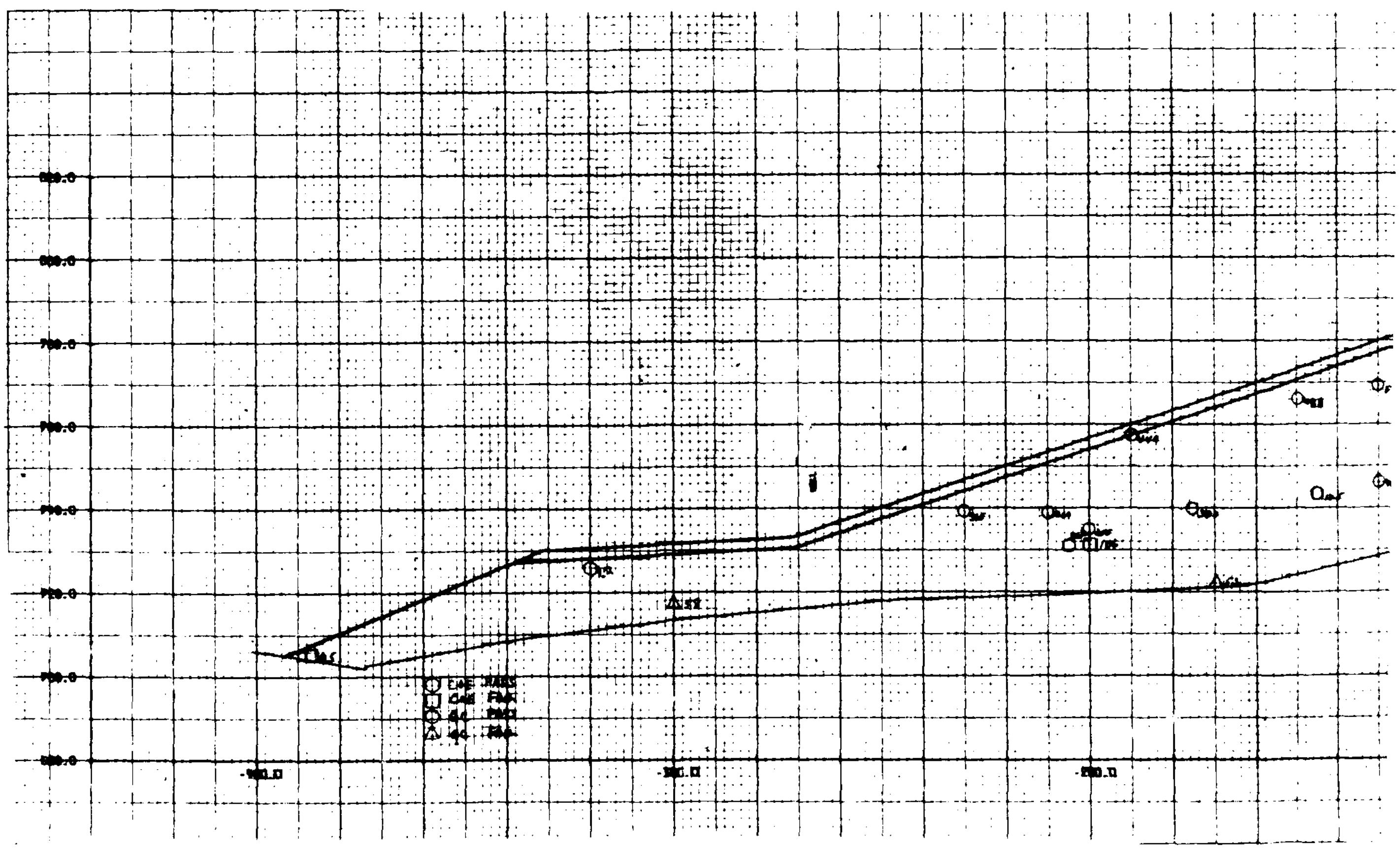
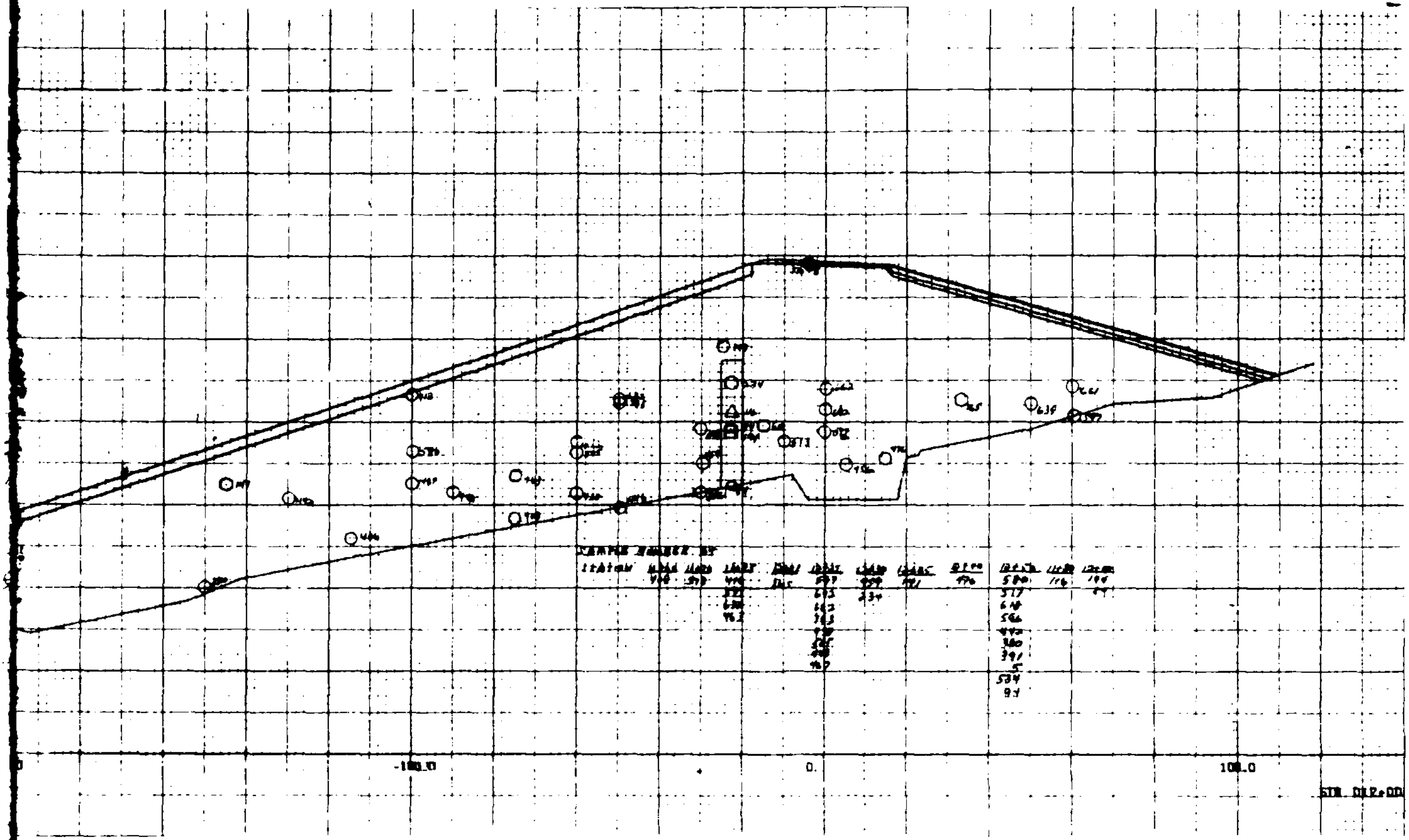


PLATE 102



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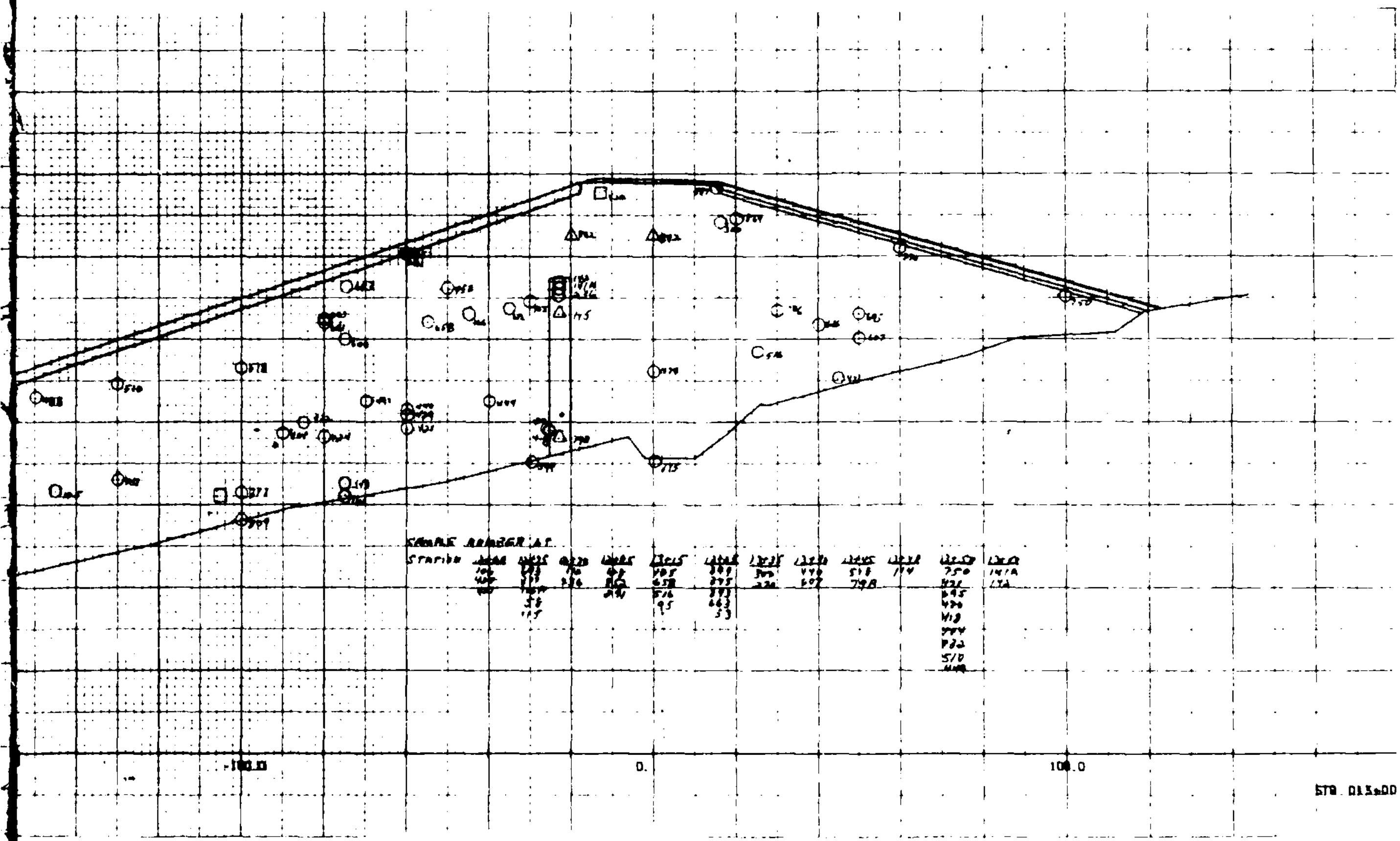
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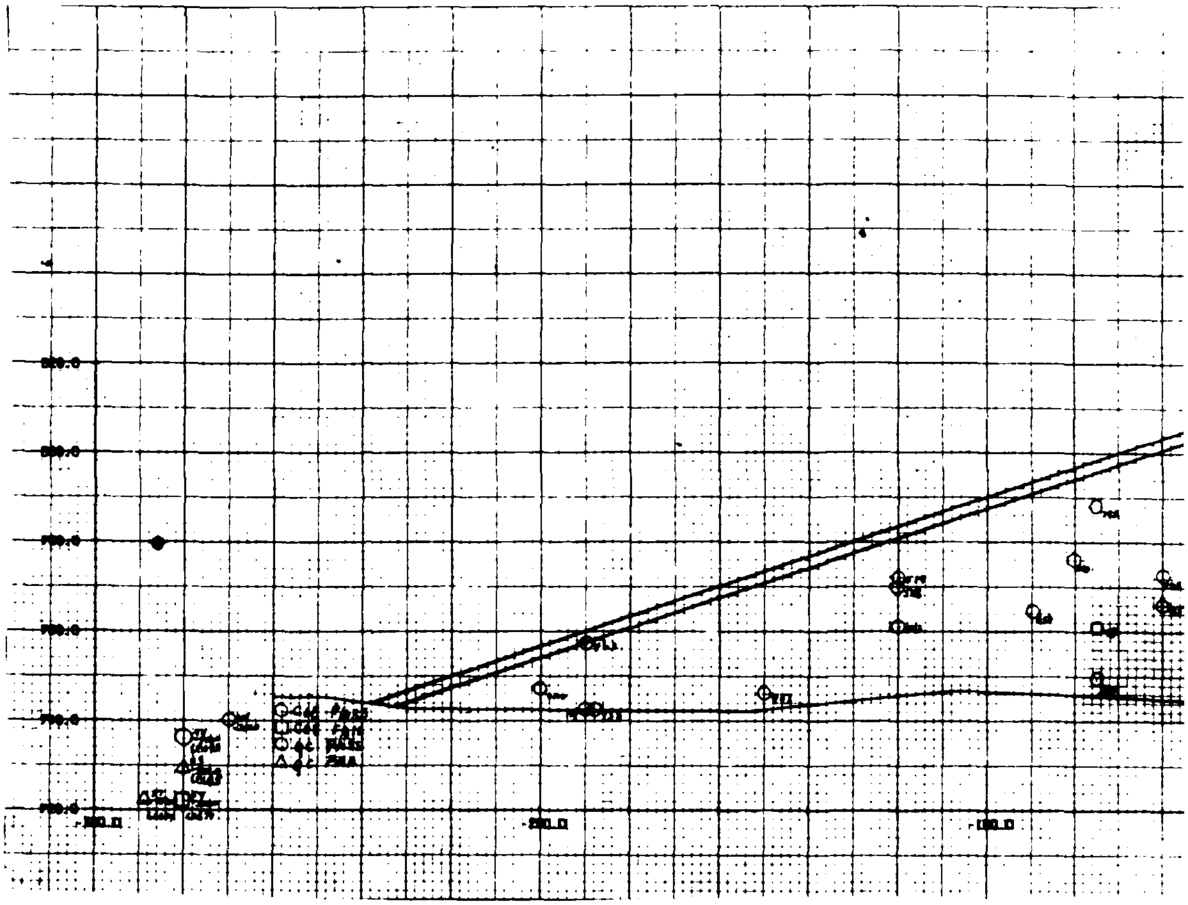
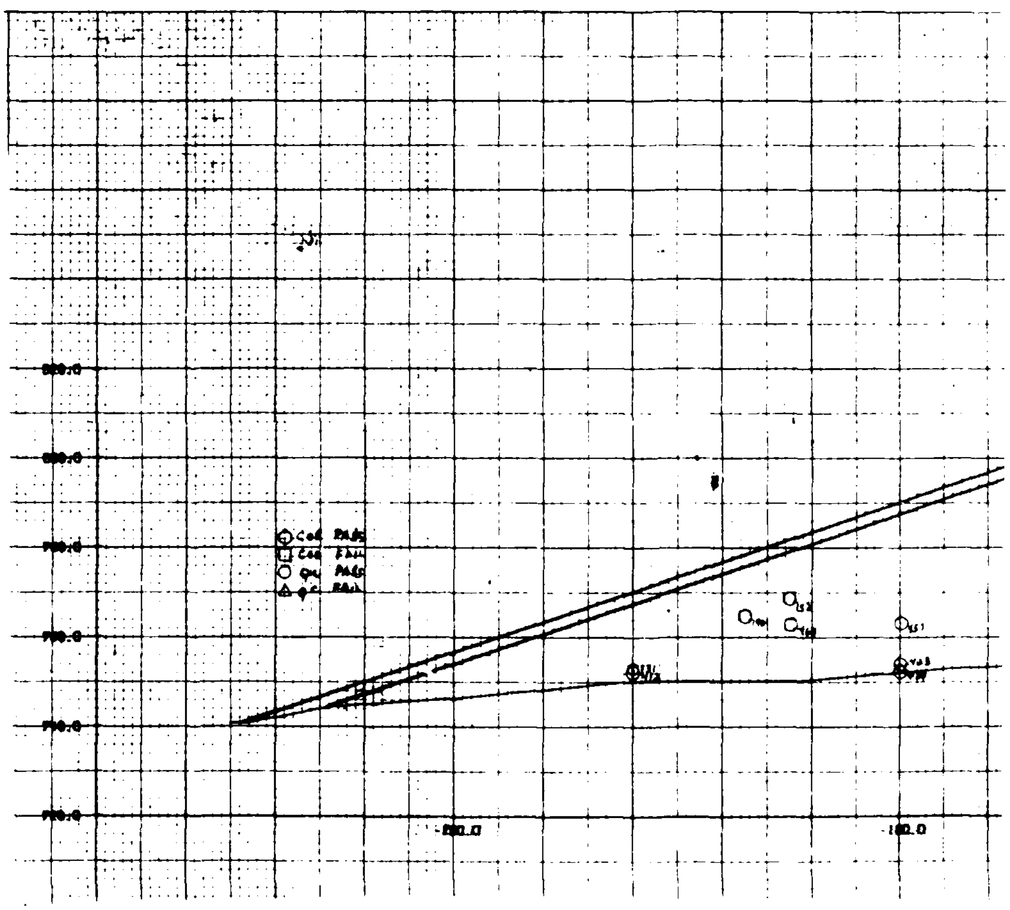
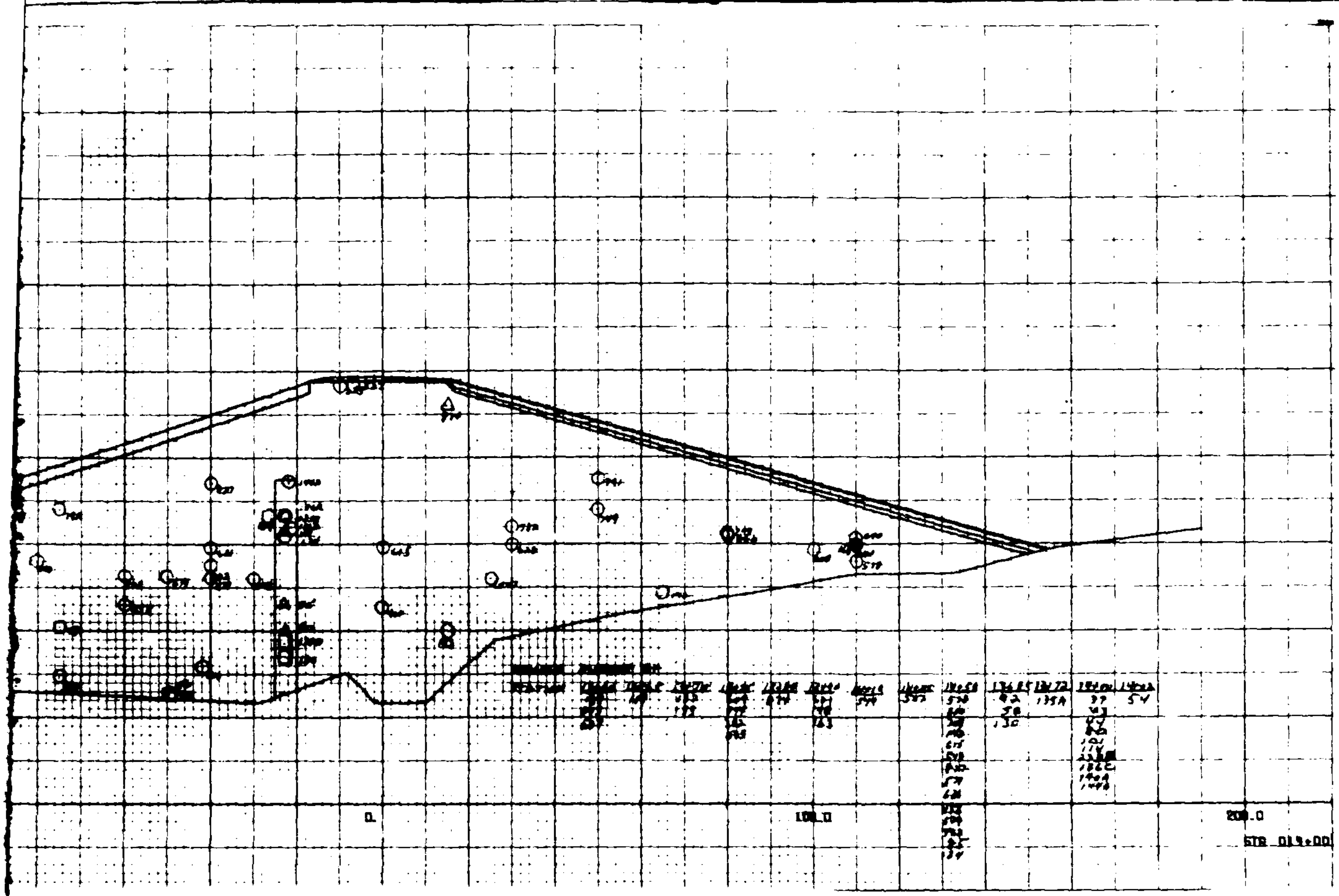
PLATE 103







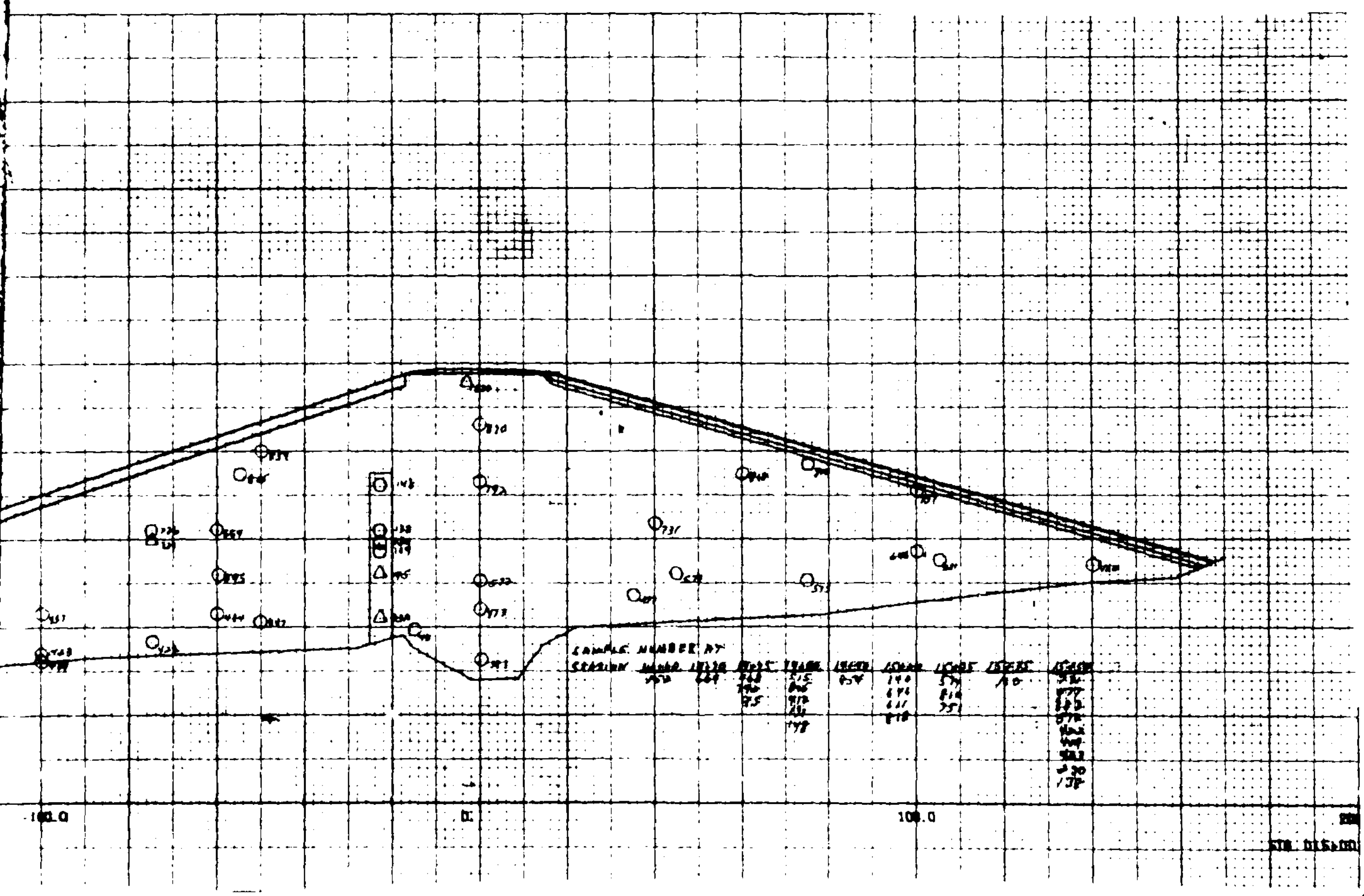
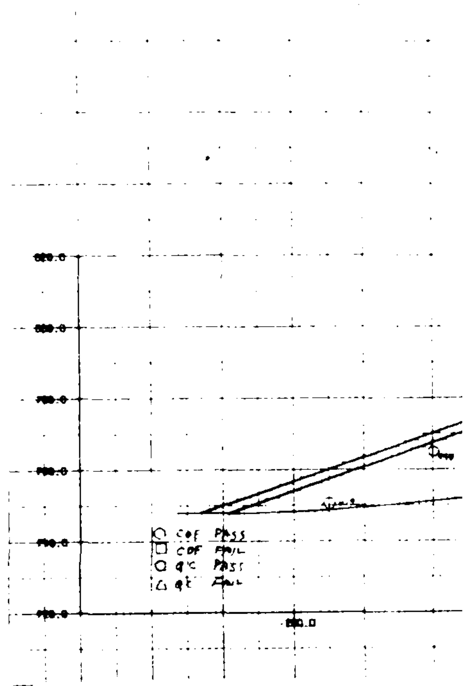


PLATE 104


CDF PASS
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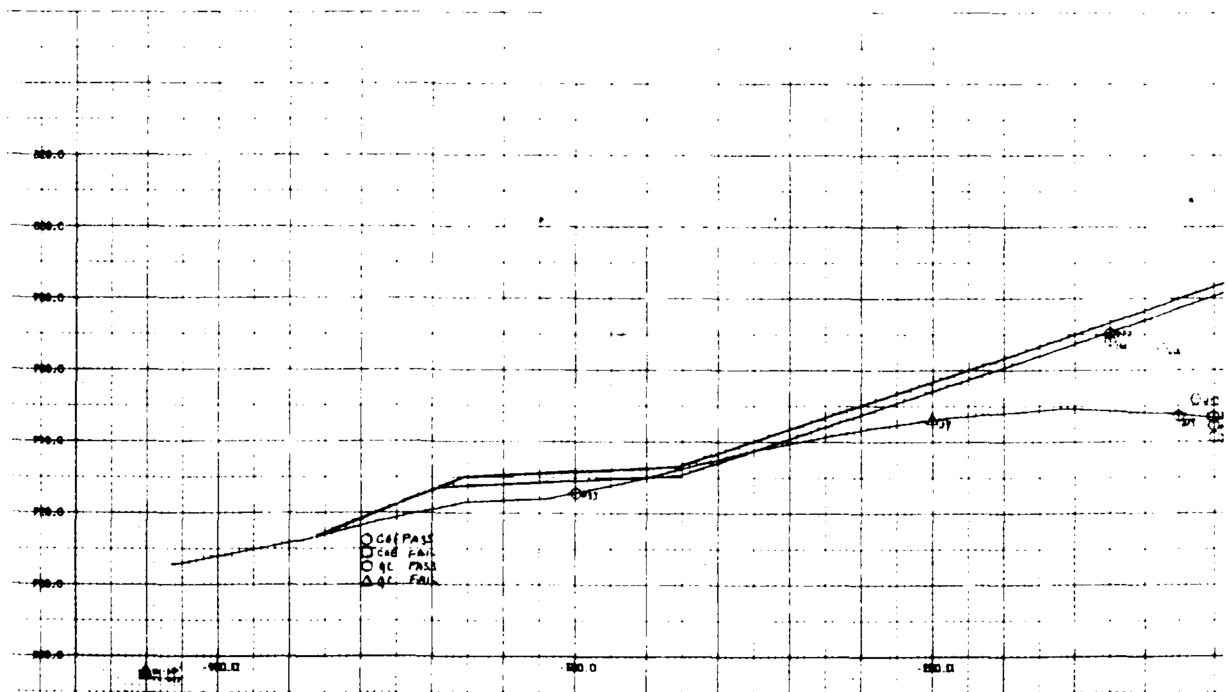
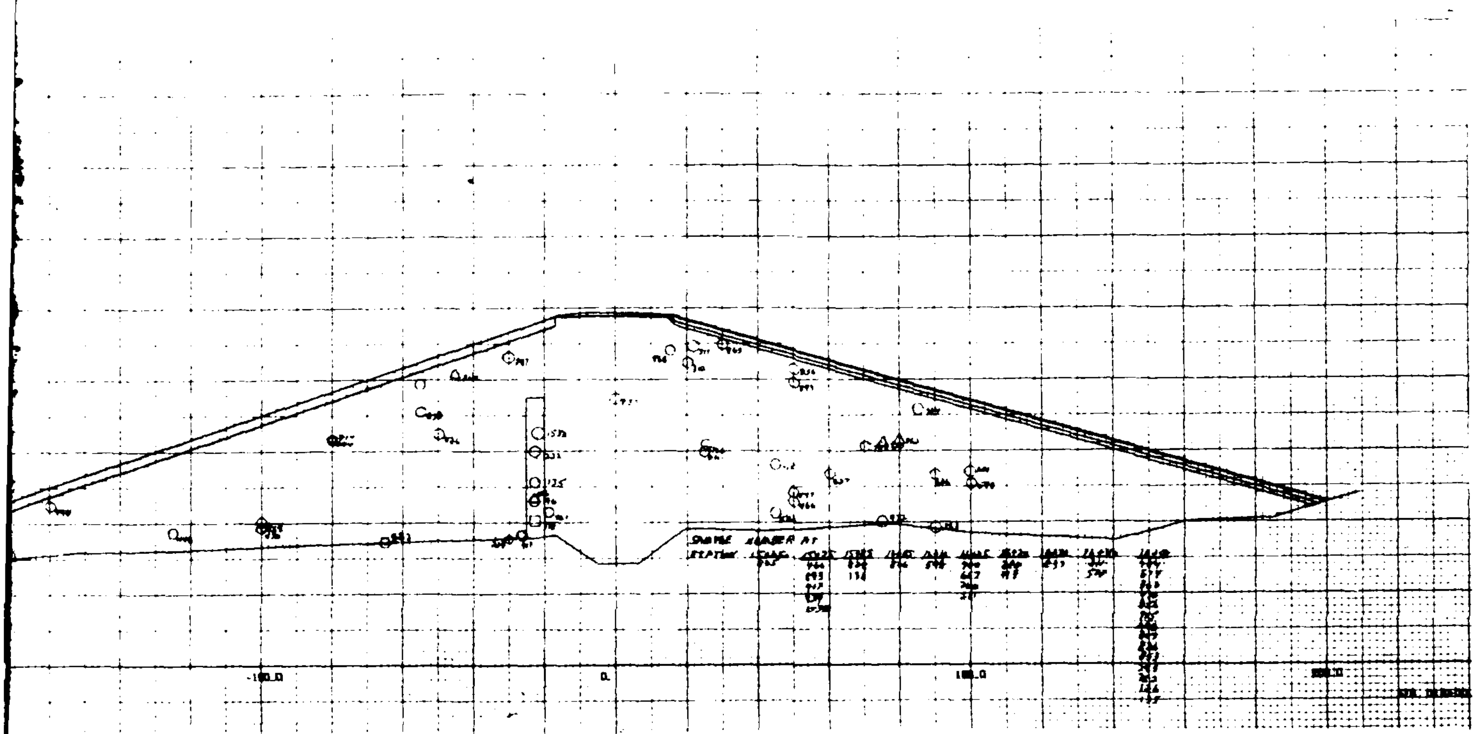
qc PASS
qc FAIL


CDF PASS
CDF FAIL
qc PASS
qc FAIL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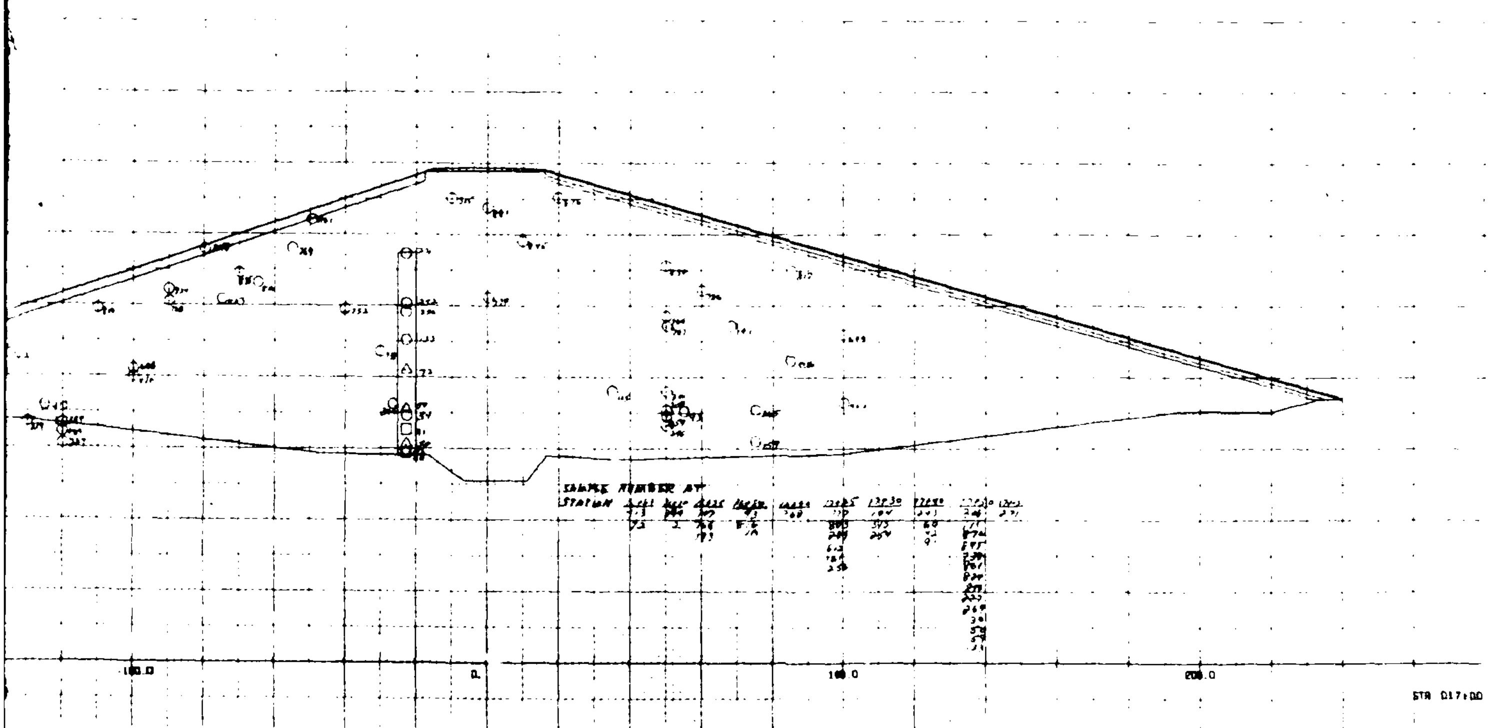
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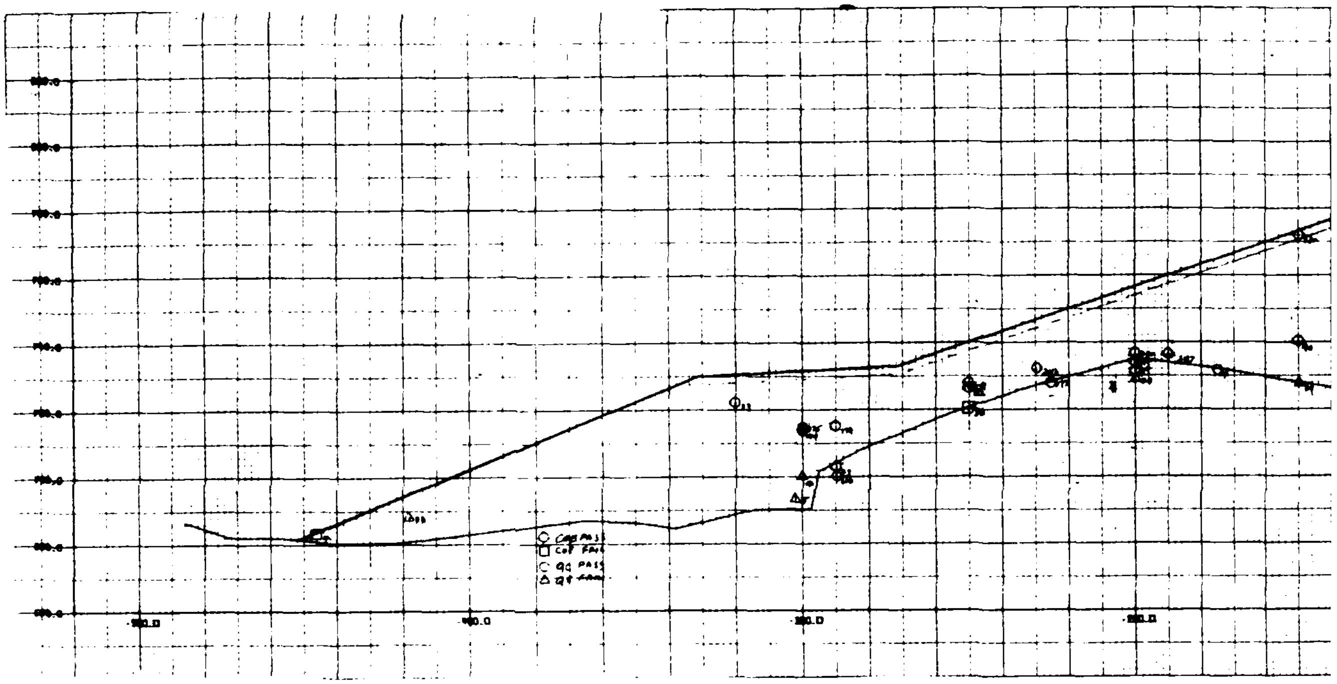
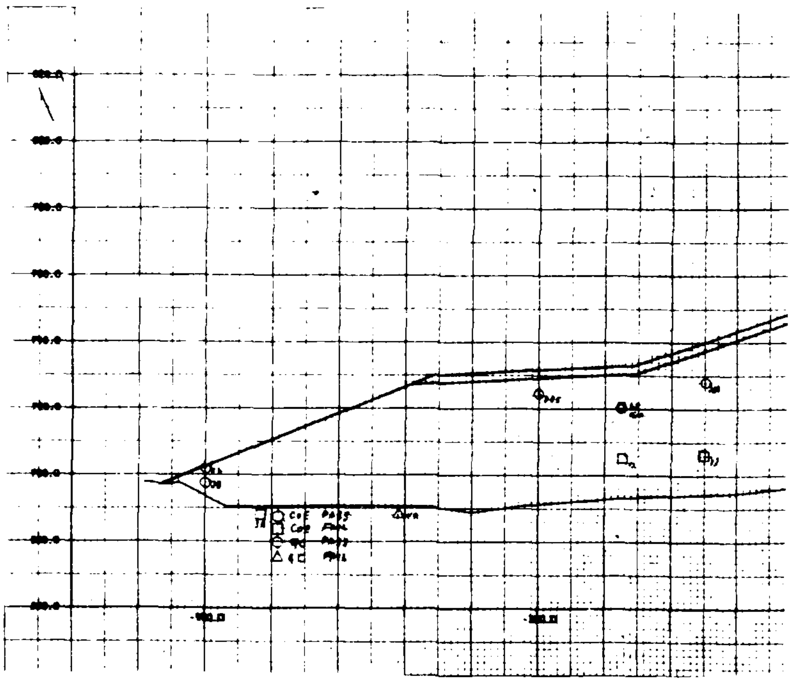
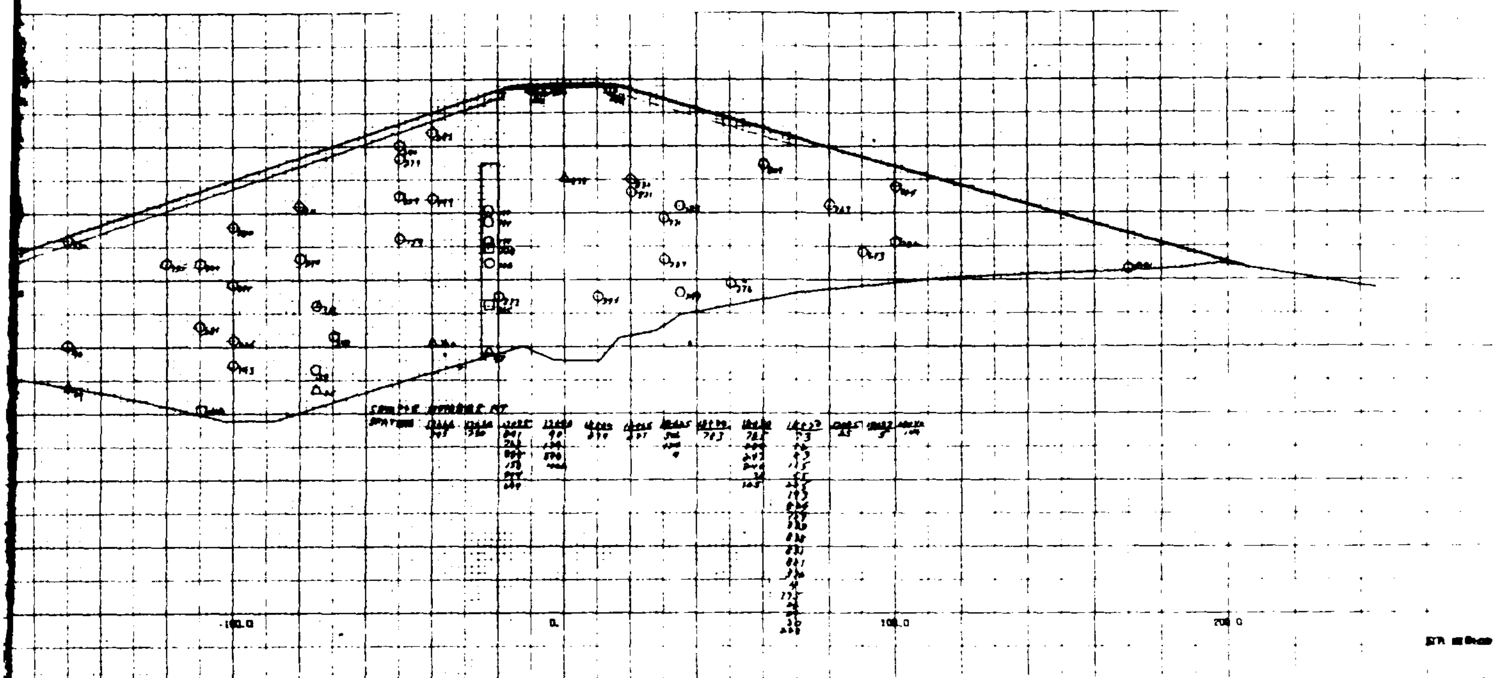
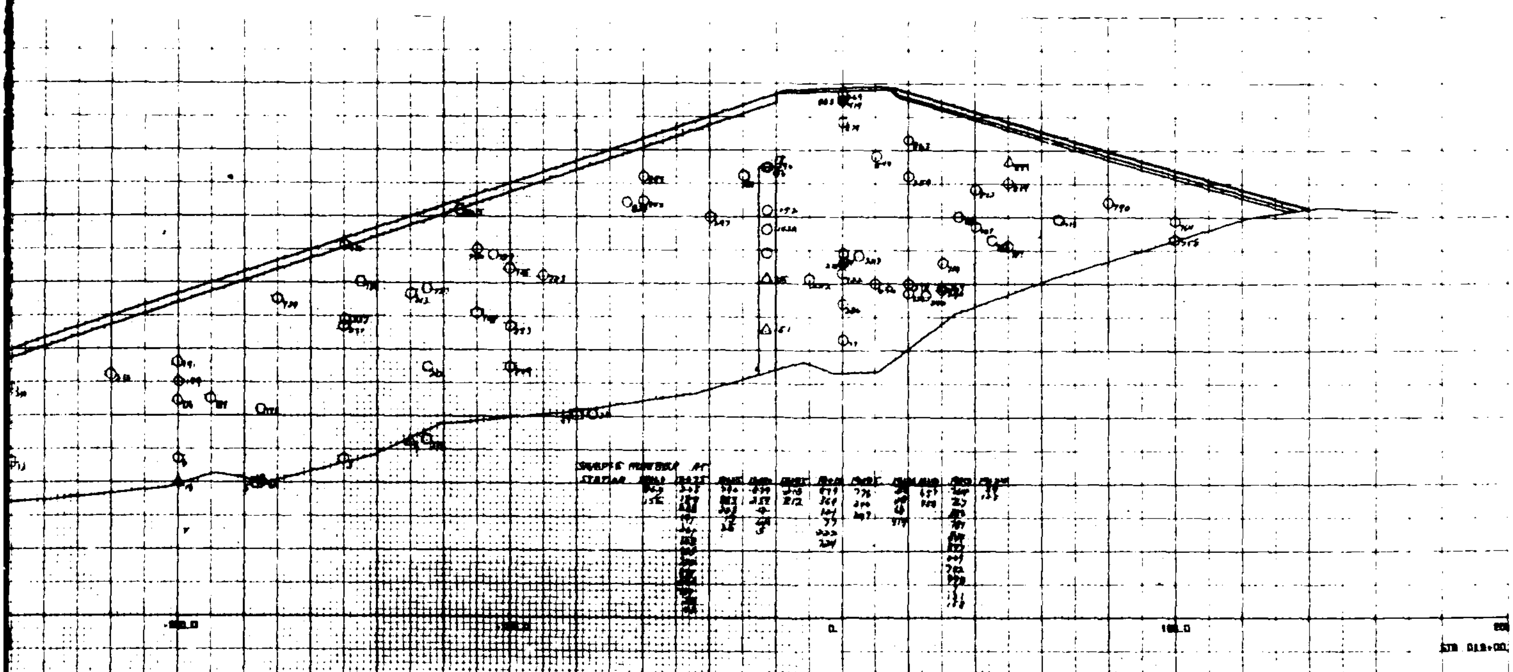
PLATE 10









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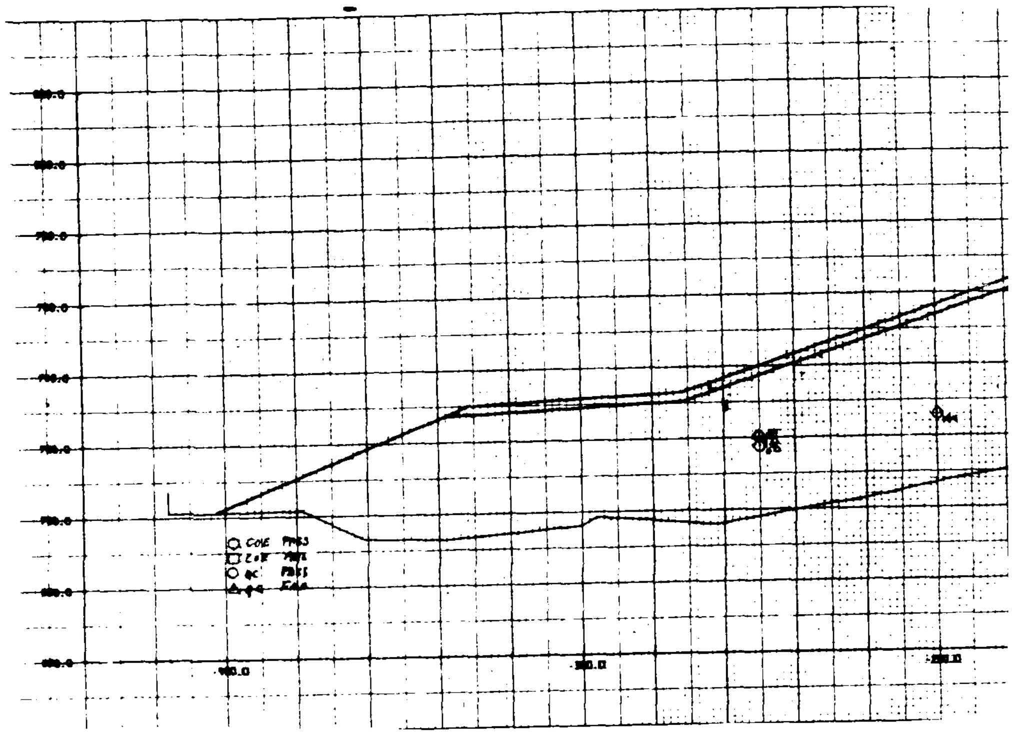
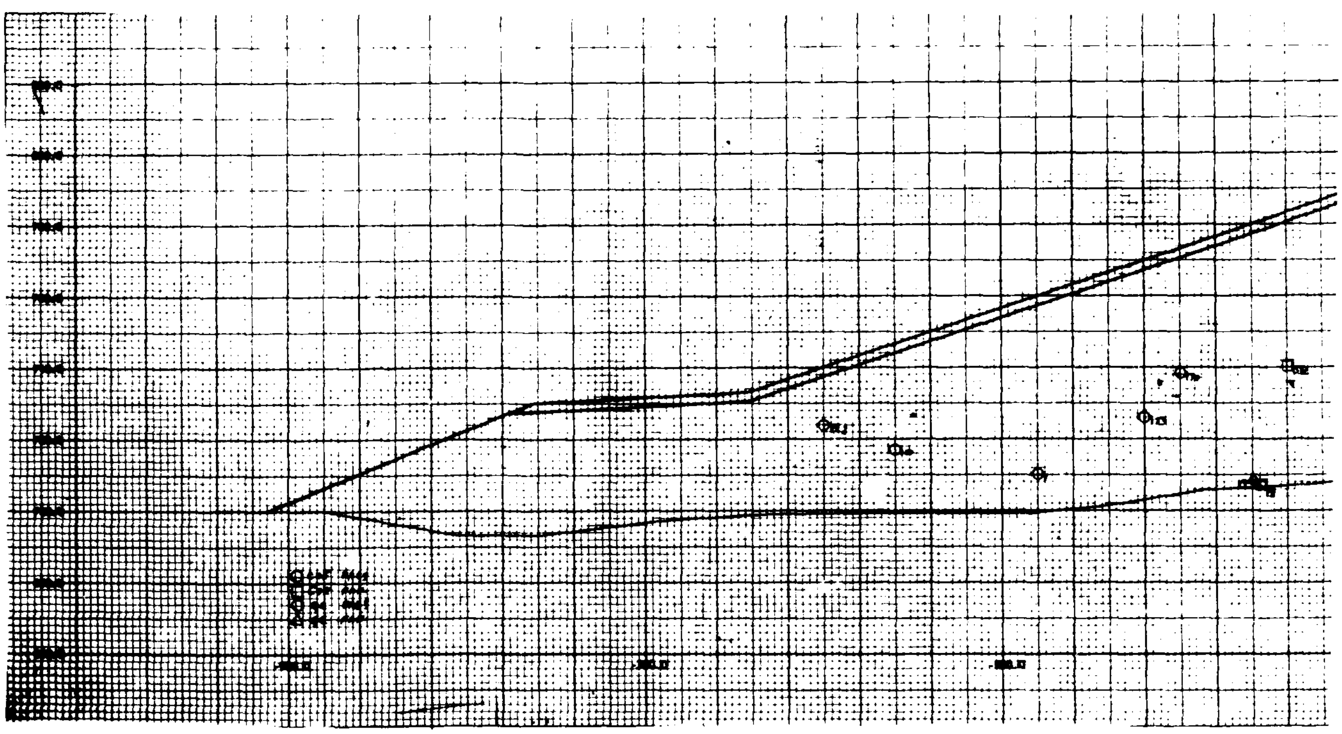
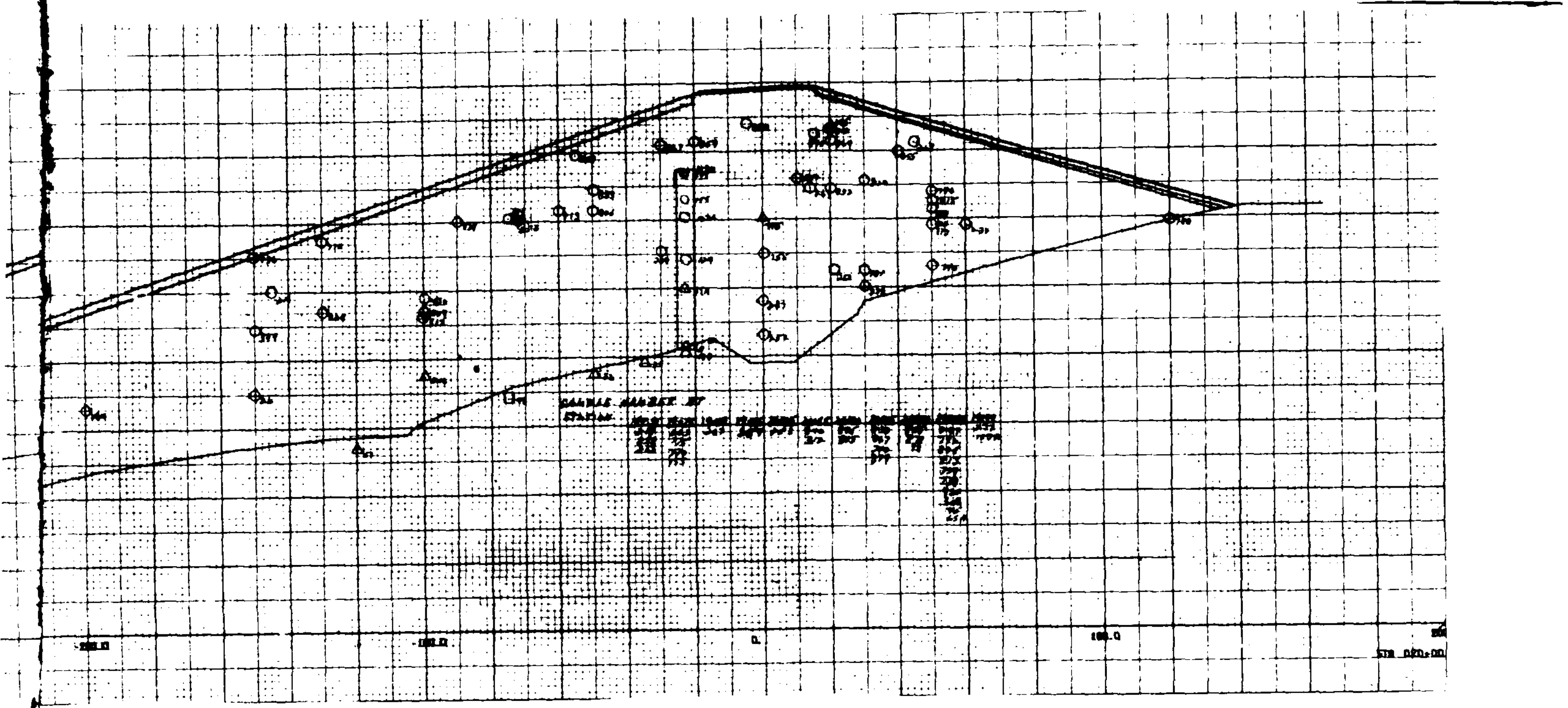






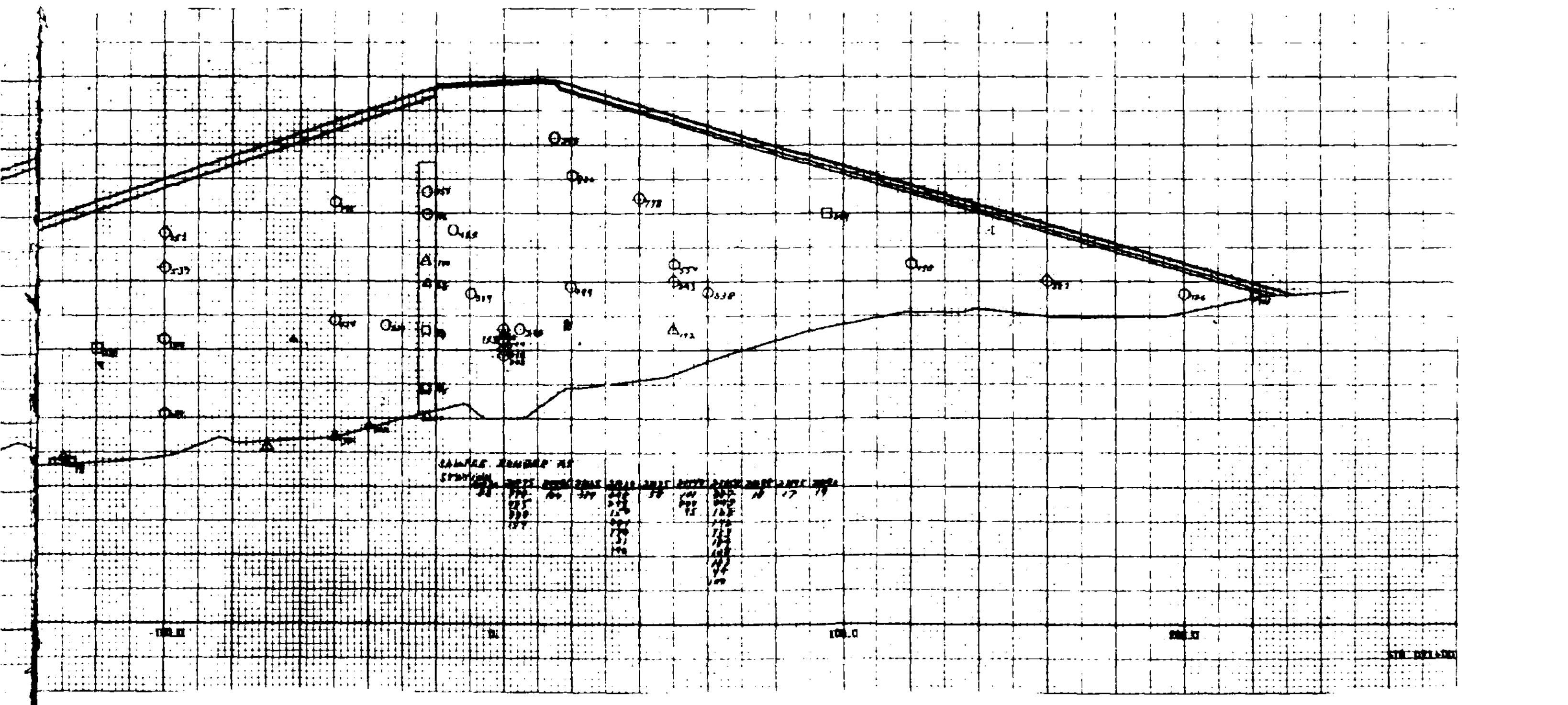
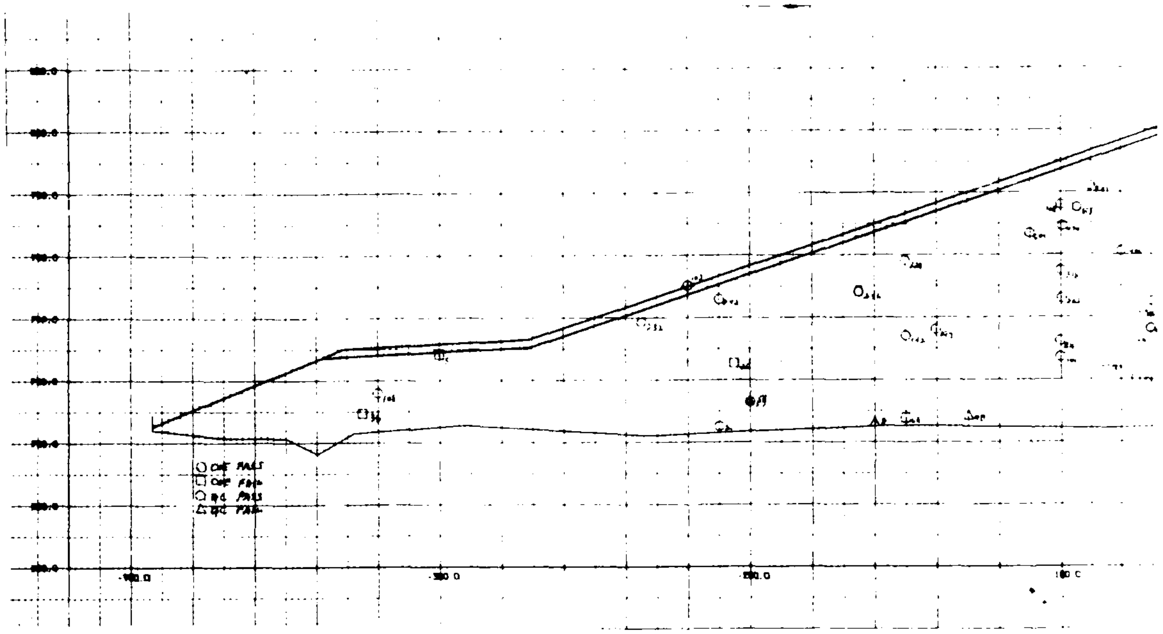
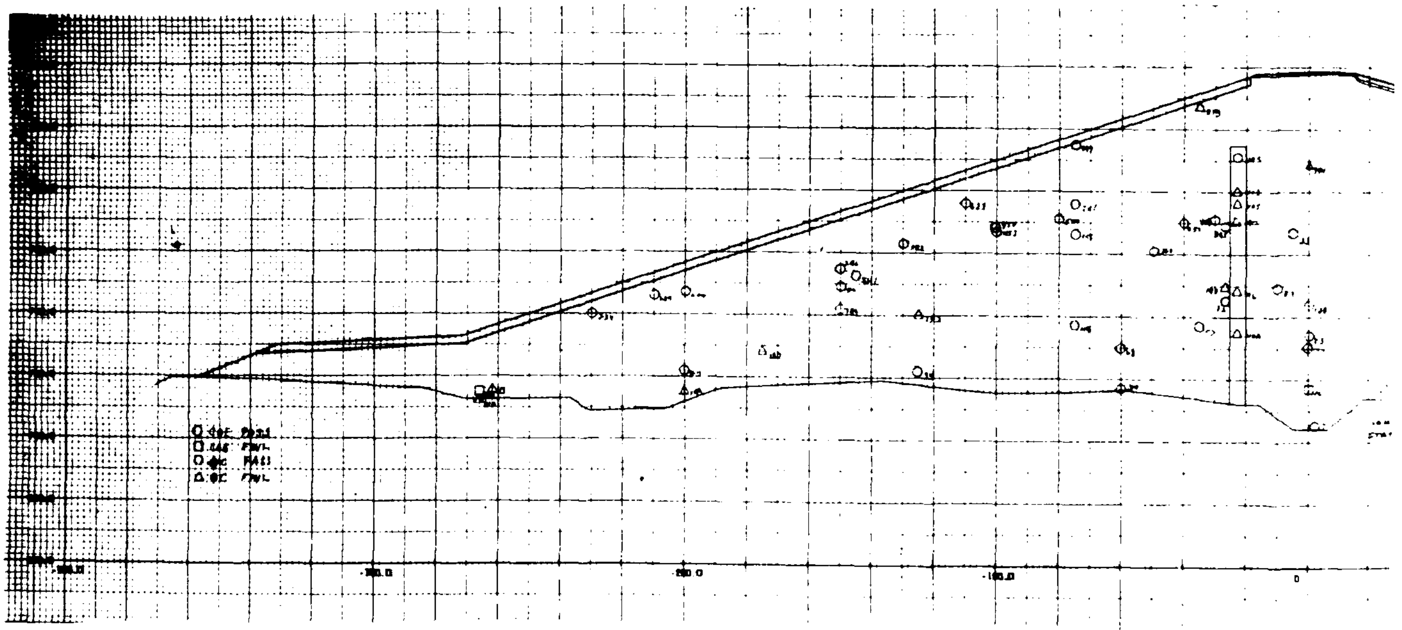
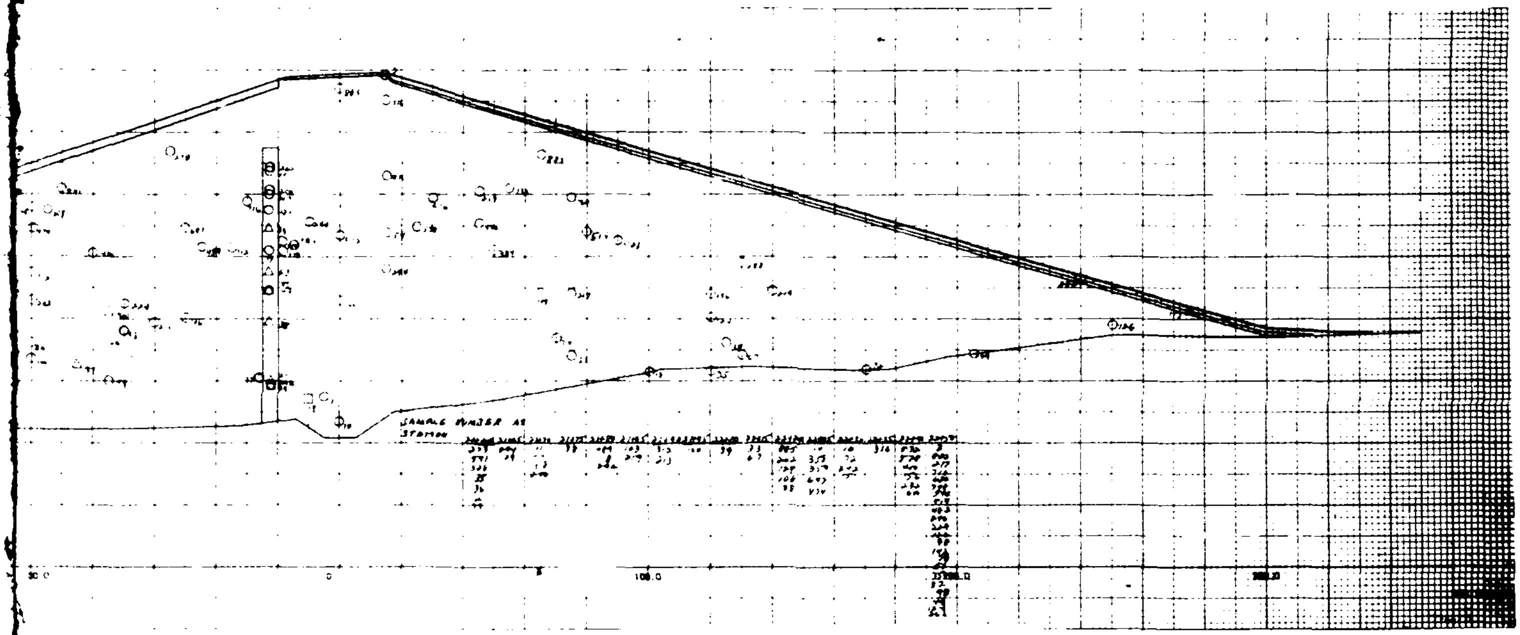


PLATE 1



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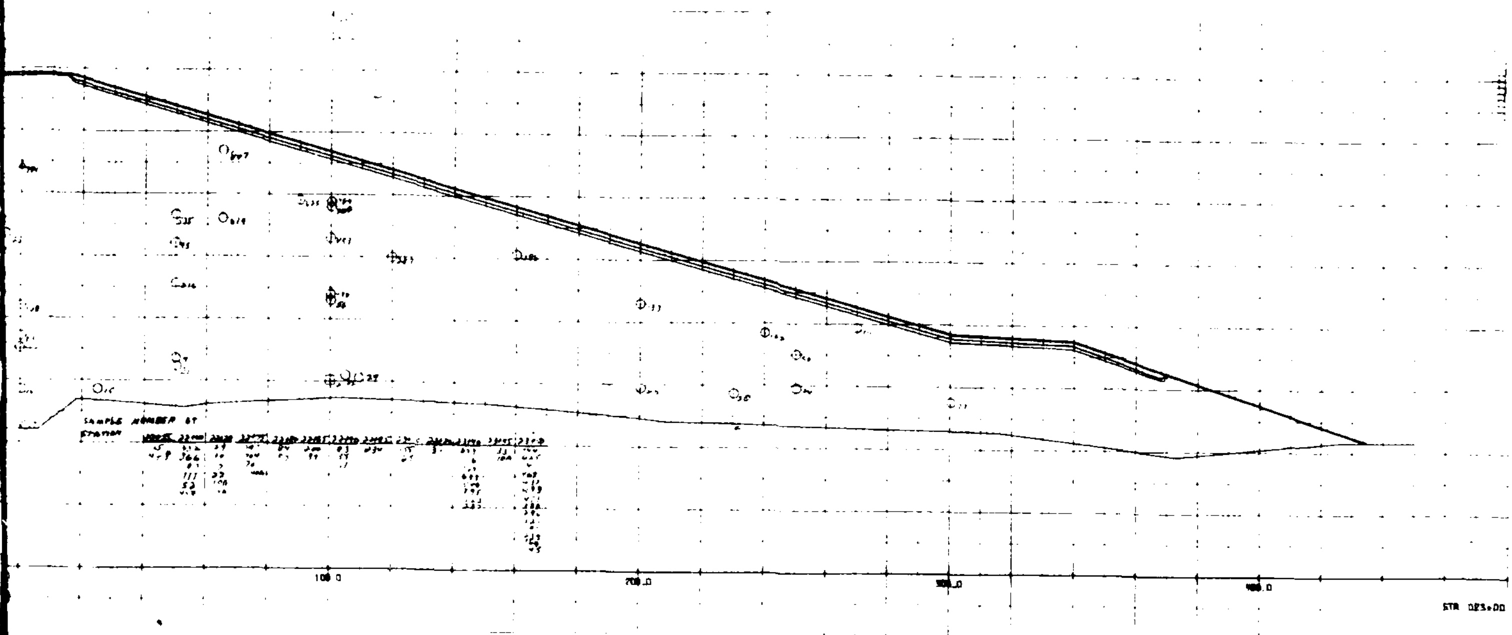
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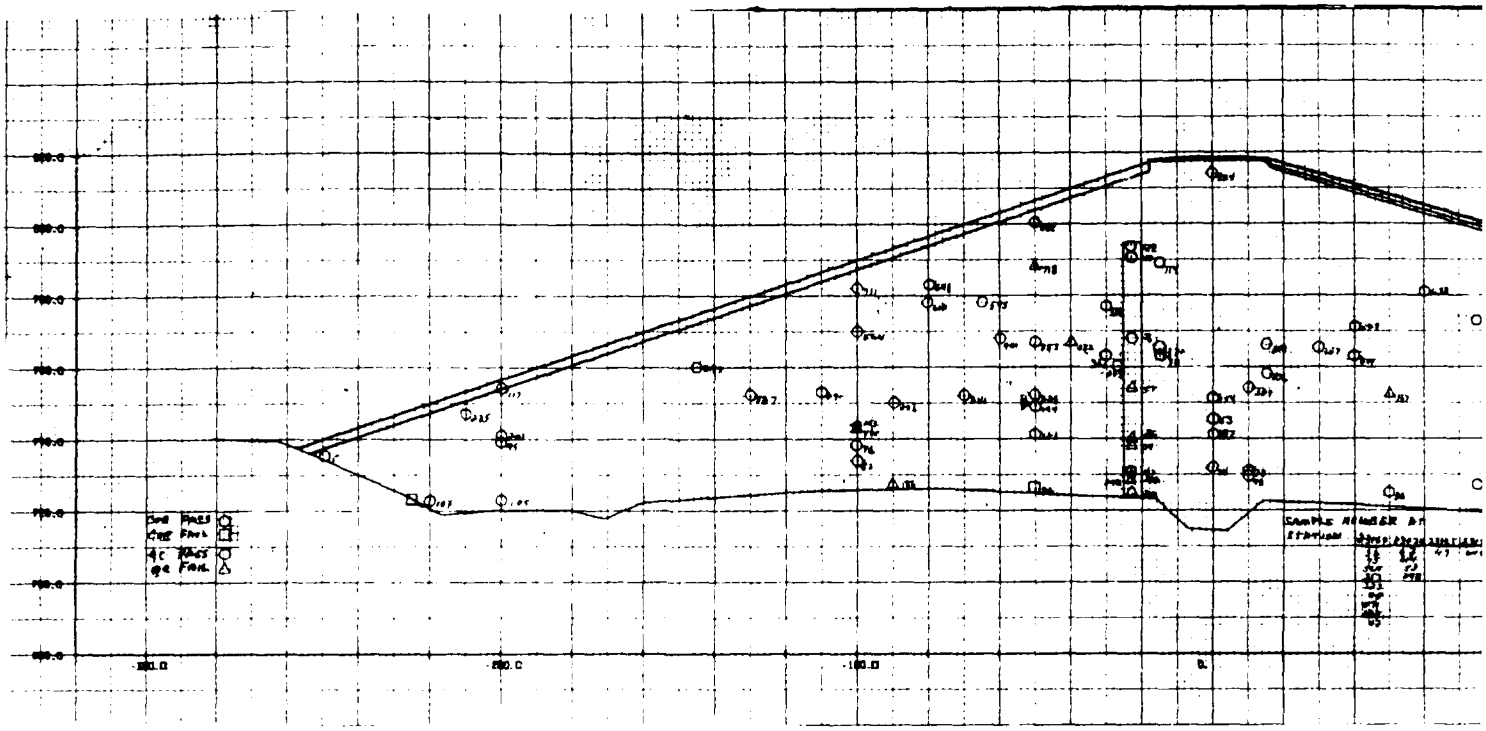
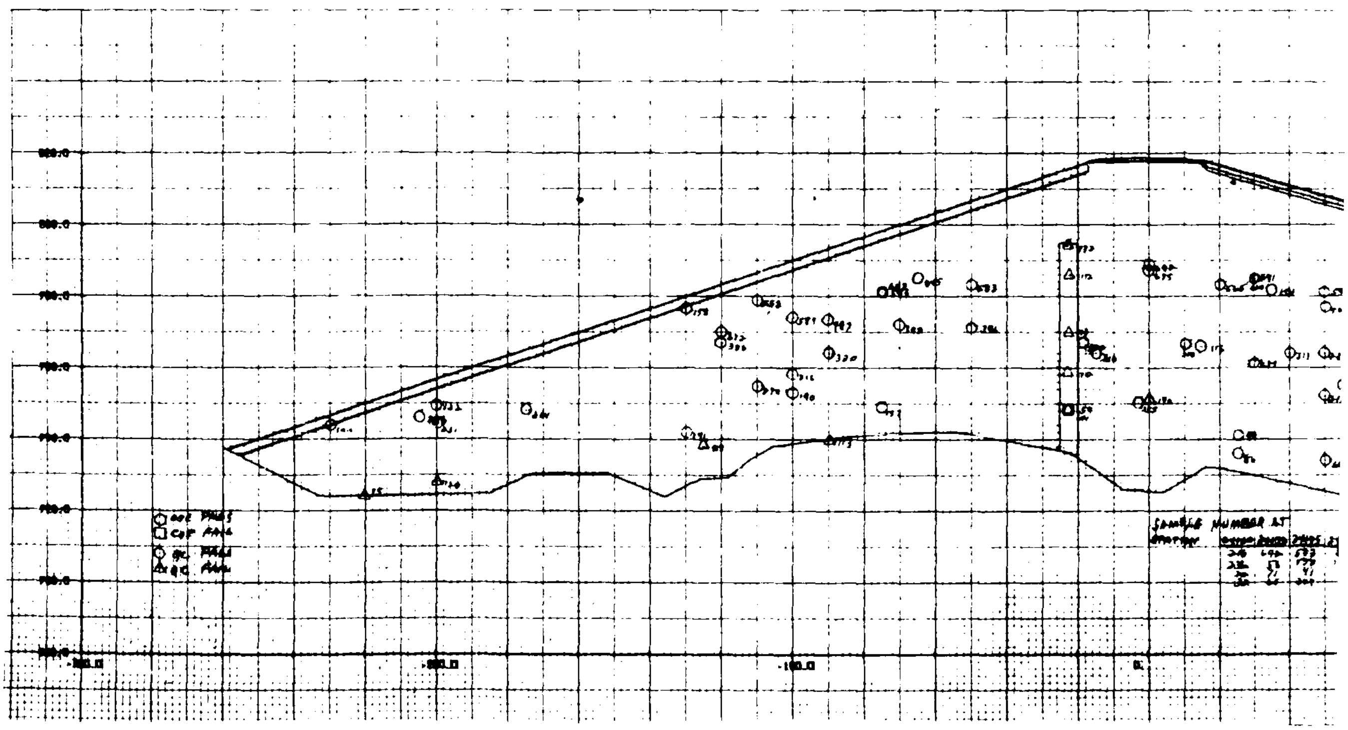
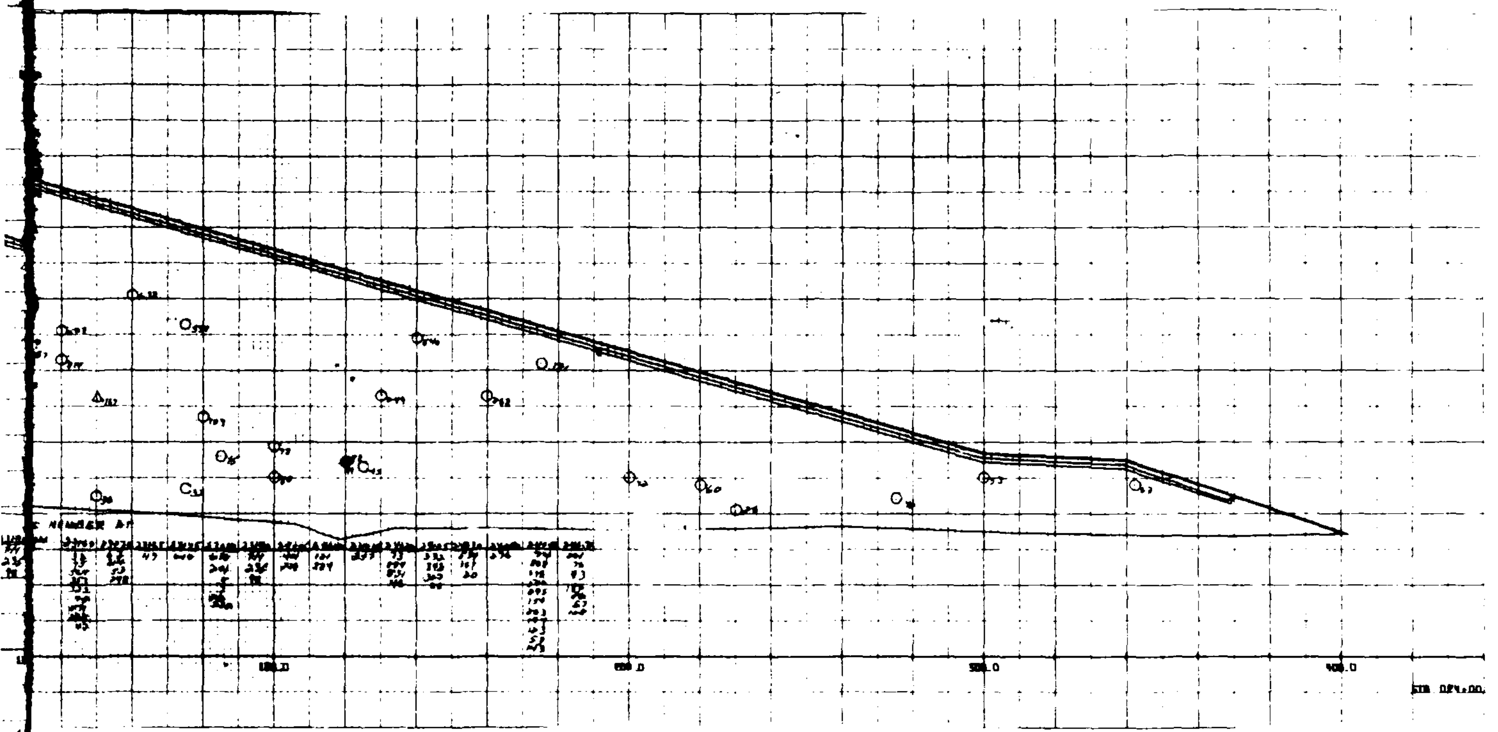
PLATE 10







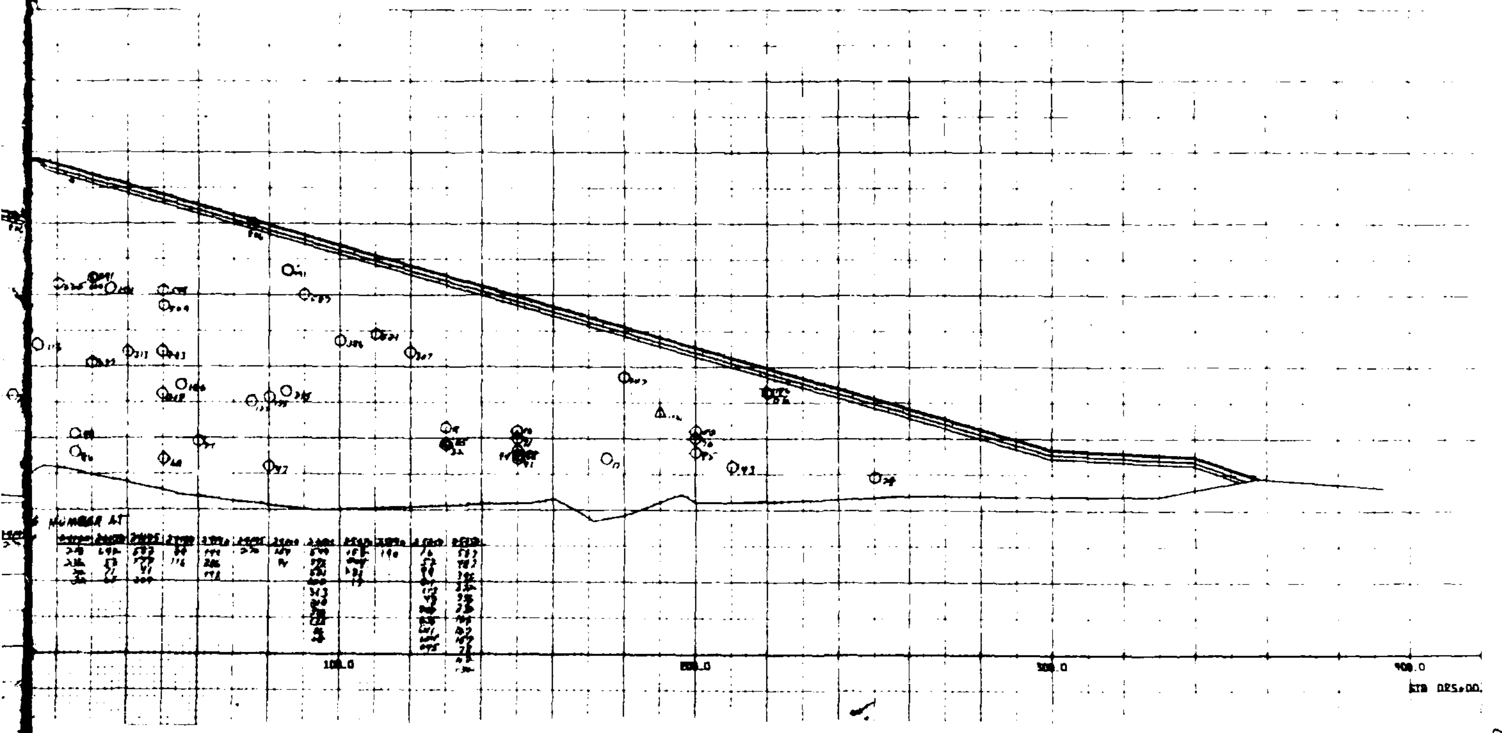
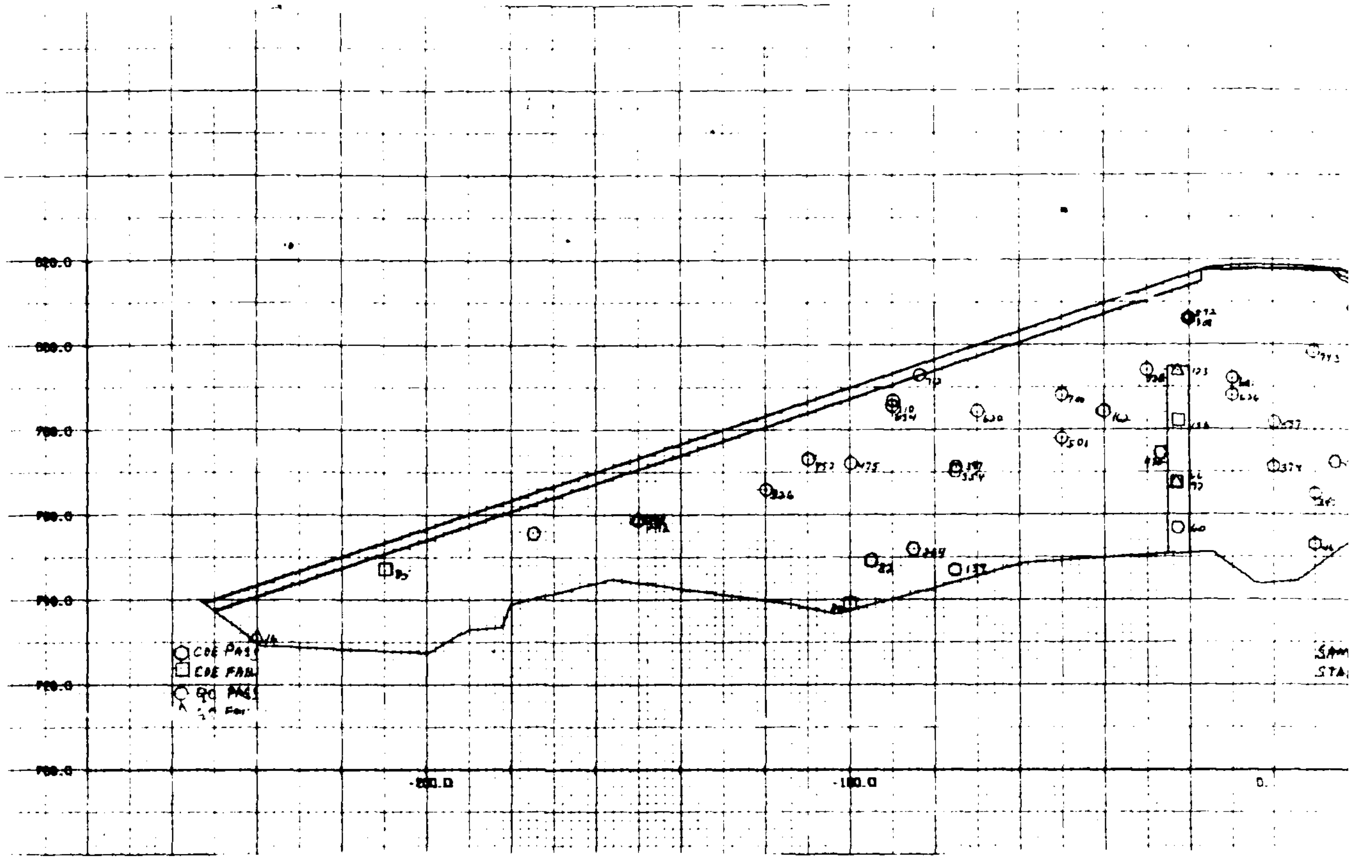


PLATE 109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QC PASS
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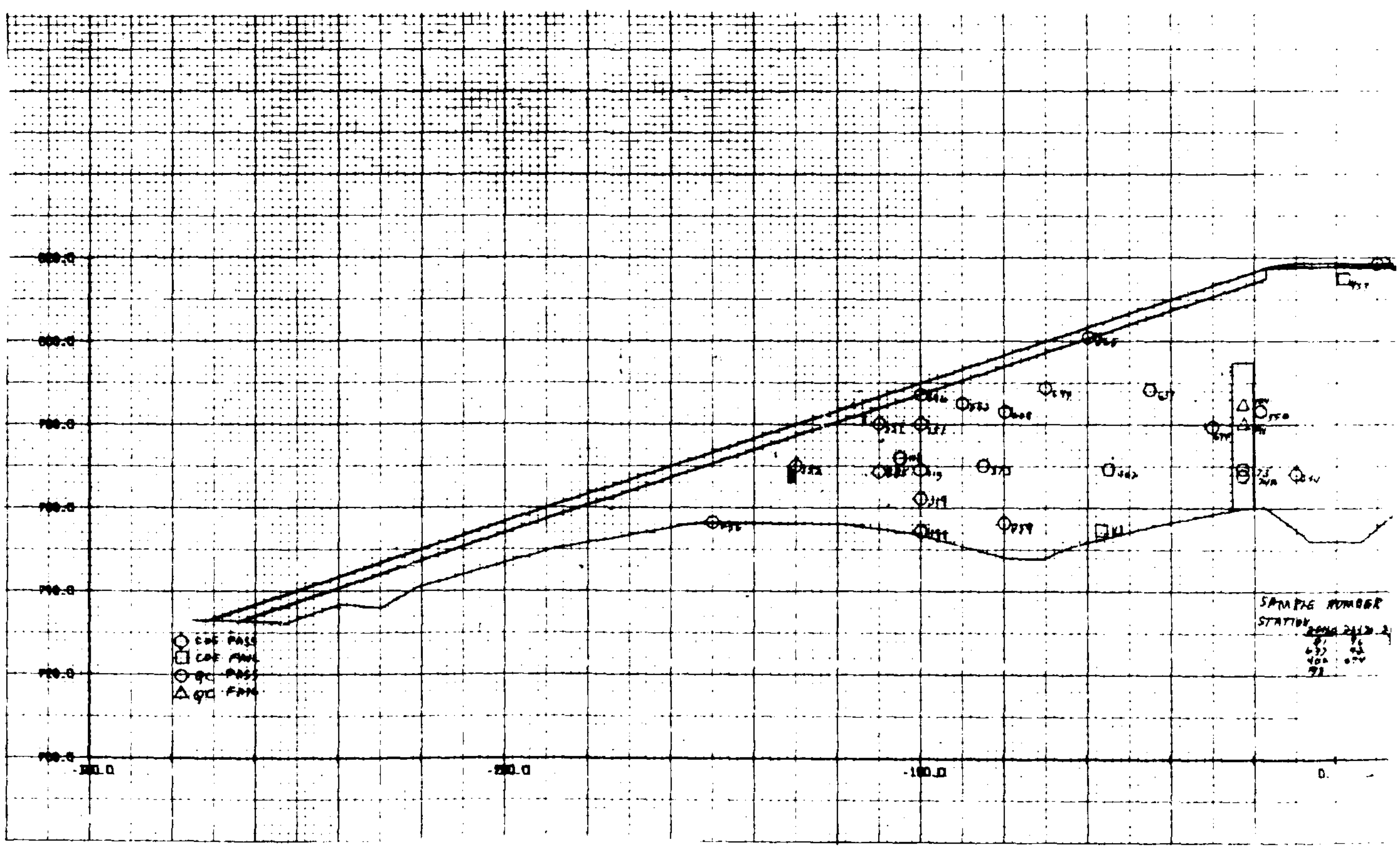
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QC PASS
QC FAIL
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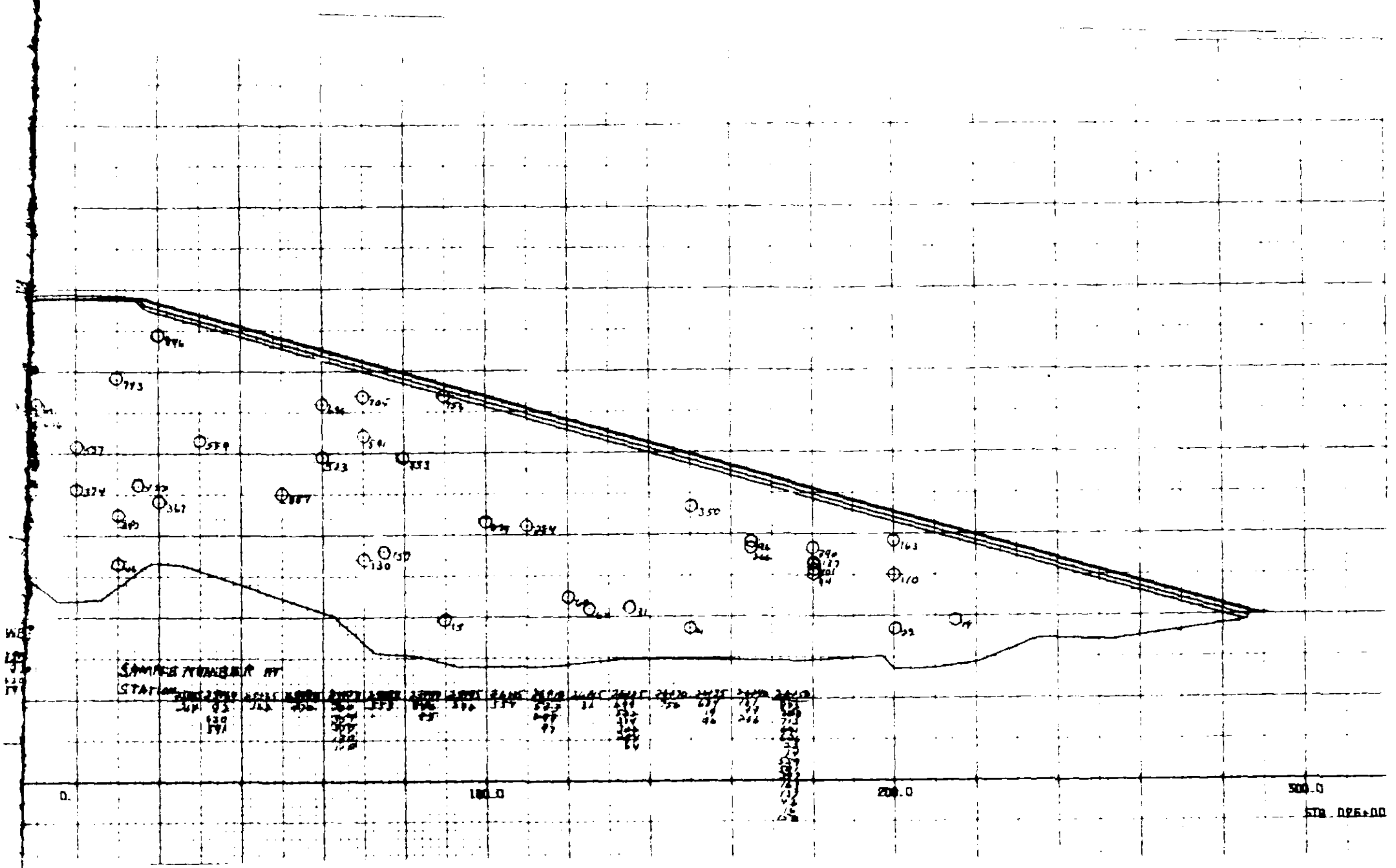
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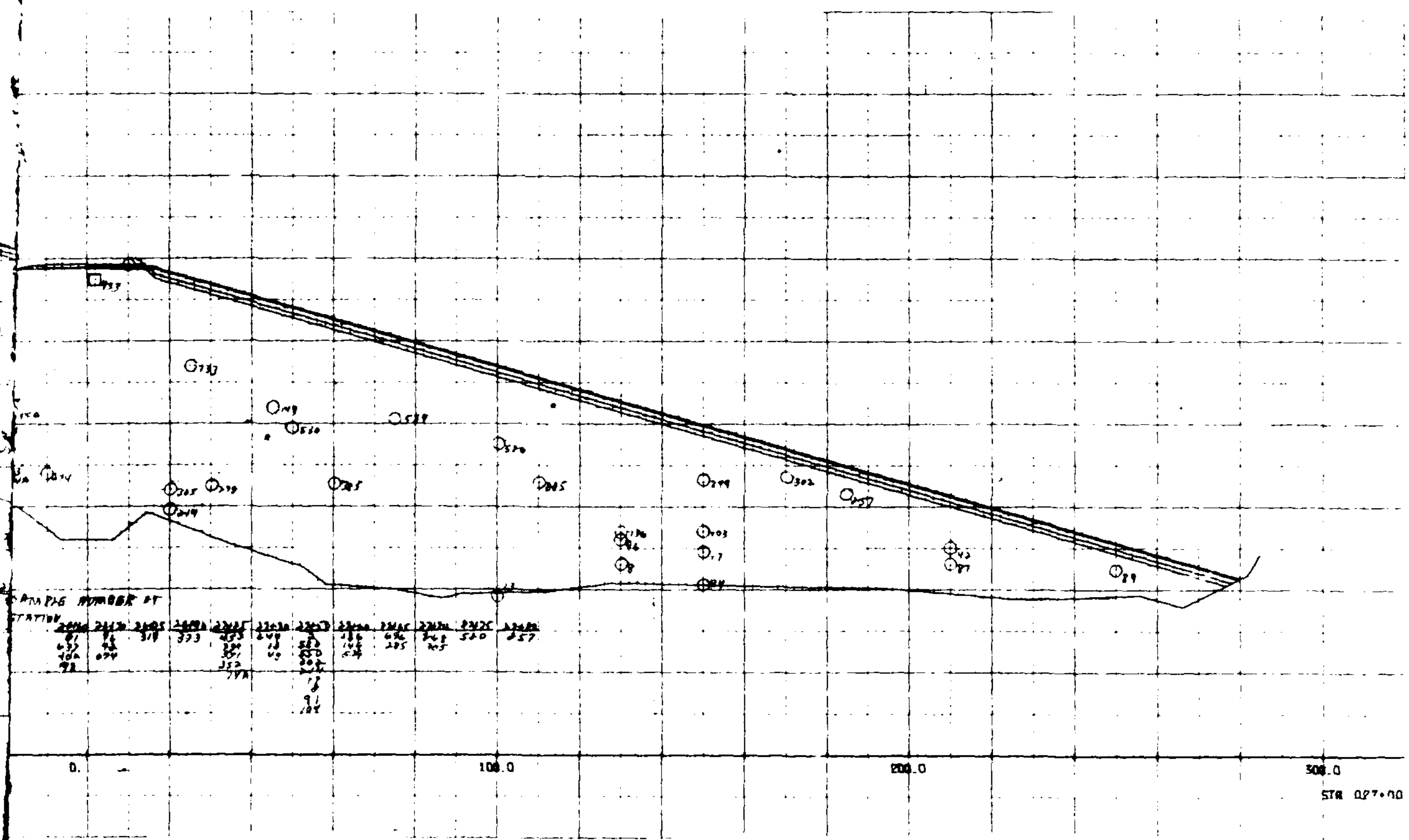
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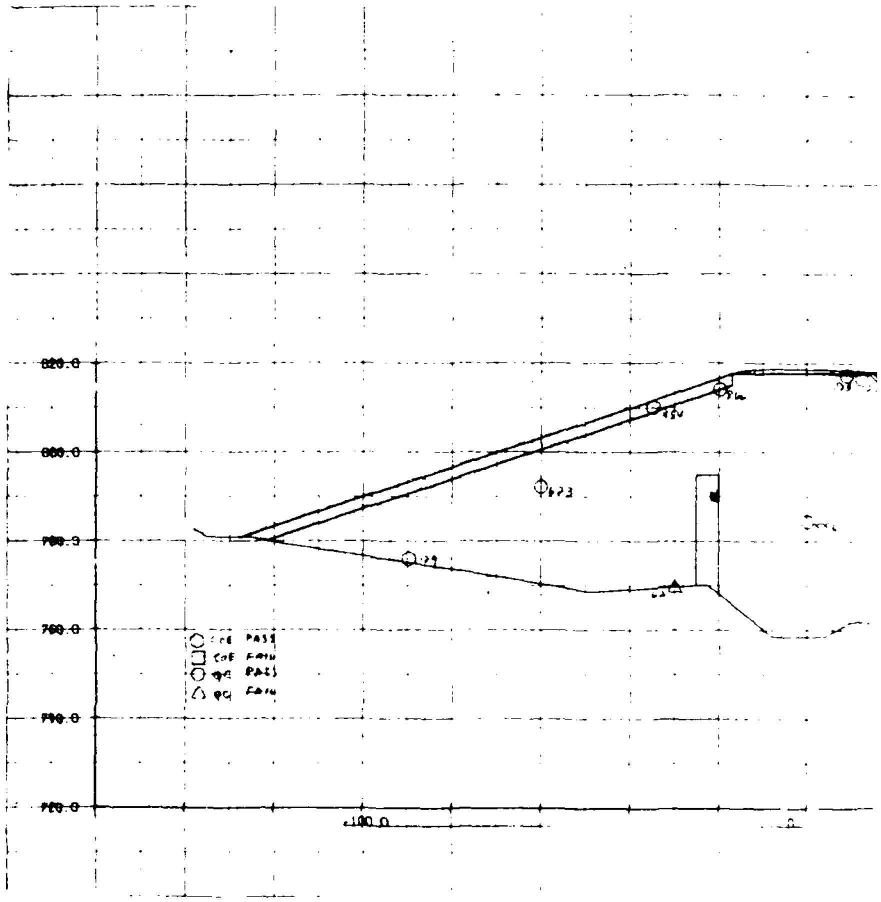
PLATE 110



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PASS
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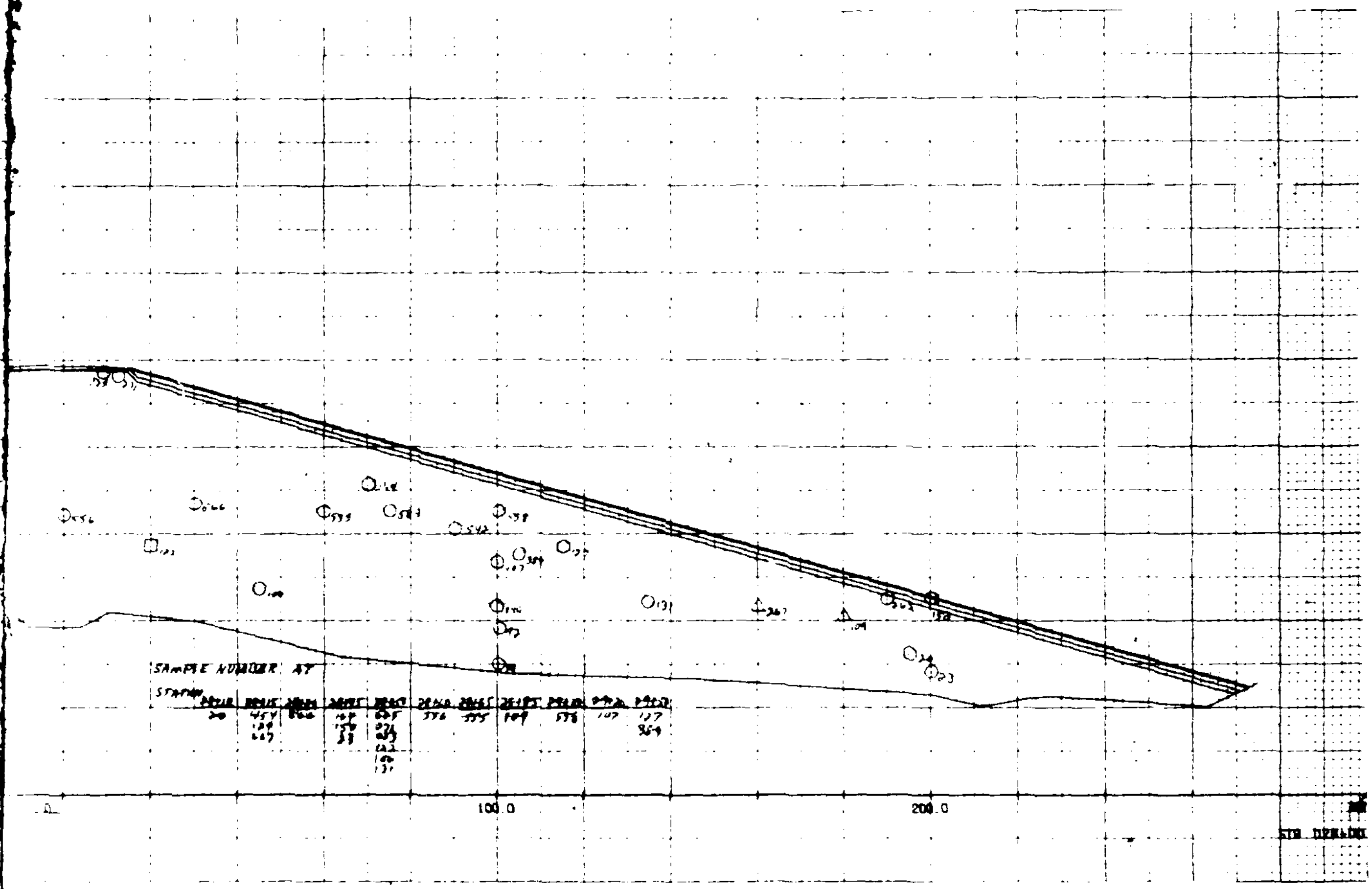


PLATE III

CONTRACTOR FIE

MATERIAL (ZONE)	NUMBER OF TESTS	DRY DENSITY				PERCENT (		
		HIGH	LOW	AVERAGE	DESIGN	HIGH	LOW	AVE(
IMPERVIOUS	803 *	139.0	102.5	120.8	130.0	109.0	91.0	10(
PERVIOUS	185 **	126.5	106.7	116.6	120.0	133.6	31.8	8

* OF THE 803 TESTS RUN ON THE IMPERVIOUS MATERIAL 10(OF OPTIMUM, 21 TESTS INDICATED THE MATERIAL WAS TO BELOW THE COMPACTION DESIRED). ALL OF THE TEST SEC WERE RETESTED AND ALL OF THESE TESTS WERE ACCEPTA

** OF THE 185 TESTS RUN ON THE PERVIOUS MATERIAL 118 TE BELOW THE COMPACTION DESIRED). ALL OF THE TEST SECTI WERE RETESTED AND ALL OF THESE TESTS WERE ACCEP

CORPS OF ENGI

MATERIAL (ZONE)	NUMBER OF TESTS	DRY DENSITY				PERCENT COM		
		HIGH	LOW	AVERAGE	DESIGN	HIGH	LOW	AVER
IMPERVIOUS	135 *	137.6	97.9	117.8	130.0	105.6	89.4	97
PERVIOUS	52 **	123.8	110.5	117.2	120.0	121.1	31.4	8:

* OF THE 135 TESTS RUN ON THE IMPERVIOUS MATERIAL 31 OF OPTIMUM, 6 TESTS INDICATED THE MATERIAL WAS TO BELOW THE COMPACTION DESIRED). ALL OF THE TEST SE WERE RETESTED AND ALL OF THESE TESTS WERE ACCEPTA

** OF THE 52 TESTS RUN ON THE PERVIOUS MATERIAL 39 TE BELOW THE COMPACTION DESIRED). ALL OF THE TEST SEC THAT WERE RETESTED AND ALL OF THESE TESTS WERE

1. STANDARD PROCTOR TEST USED ON THE IMPERVIOUS MATERIA
2. NOT APPLICABLE - NO MOISTURE CONTROL SPECIFIED
3. INDICATE RESULTS OF ALL TESTS FOR HIGH AND LOW VALUE AVERAGE VALUES

COM R FIELD COMPACTION CONTROL - SADDLE DAM

PA ENT COMPACTION ①③			WATER CONTENT ③				DEVIATION FROM OPTIMUM ③			
E	AVERAGE	DESIRED	HIGH	LOW	AVERAGE	DESIGN	HIGH	LOW	AVERAGE	SPECIFIED
	100.0	95.0	21.7	5.9	13.8	15.0	+3.1	-3.6	-.30	+1, -2
	82.7	80.0	N/A②	N/A②	N/A②	N/A②	N/A②	N/A②	N/A②	N/A②

EST 108 TESTS FAILED (81 TESTS INDICATED THE MATERIAL WAS TOO DRY
'ETS TOO WET OF OPTIMUM AND 6 TESTS INDICATED THE MATERIAL WAS
NS SECTIONS THAT FAILED WERE REWORKED. THERE WERE 14 AREAS THAT
E. CEPTABLE.

FA 8 TESTS FAILED (ALL OF THE TESTS INDICATED THE MATERIAL WAS
T ECTIONS THAT FAILED WERE REWORKED. THERE WERE 35 AREAS THAT
LE CCEPTABLE.

ER ENGINEERS ACCEPTANCE TESTS - SADDLE DAM

CTIO T COMPACTION ①③			WATER CONTENT ③				DEVIATION FROM OPTIMUM ③			
E	AVERAGE	DESIRED	HIGH	LOW	AVERAGE	DESIGN	HIGH	LOW	AVERAGE	SPECIFIED
	97.5	95.0	21.0	6.7	13.9	15.0	+3.9	-3.2	+.40	+1, -2
	83.6	80.0	N/A②	N/A②	N/A②	N/A②	N/A②	N/A②	N/A②	N/A②

ES 31 TESTS FAILED (17 TESTS INDICATED THE MATERIAL WAS TOO DRY
WE AS TOO WET OF OPTIMUM AND 8 TESTS INDICATED THE MATERIAL WAS
ION T SECTIONS THAT FAILED WERE REWORKED. THERE WERE 5 AREAS THAT
E. EPTABLE.

S 9 TESTS FAILED (ALL OF THE TESTS INDICATED THE MATERIAL WAS
ONS SECTIONS THAT FAILED WERE REWORKED. THERE WERE 19 AREAS
CE ERE ACCEPTABLE.

RE ERIAL, RELATIVE DENSITY TEST USED ON THE PERVIOUS MATERIAL

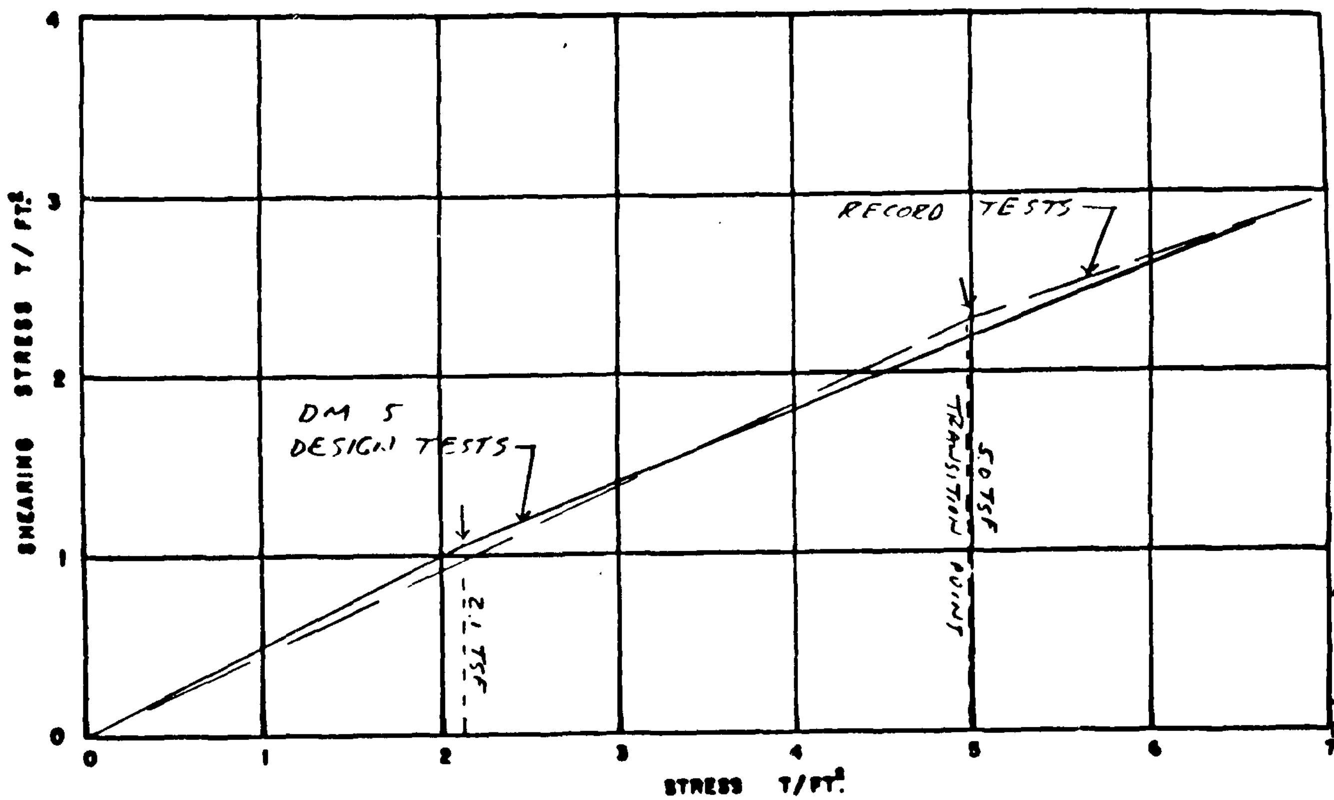
AN ALUES AND INDICATE RESULTS OF ACCEPTABLE TESTS AND RETESTS FOR

HARSHA LAKE OHIO

IMPERVIOUS CLAY CORE

COMPARISON DESIGN ENVELOPE VS. RECORD TEST ENVELOPE

(R+S/2 & S)



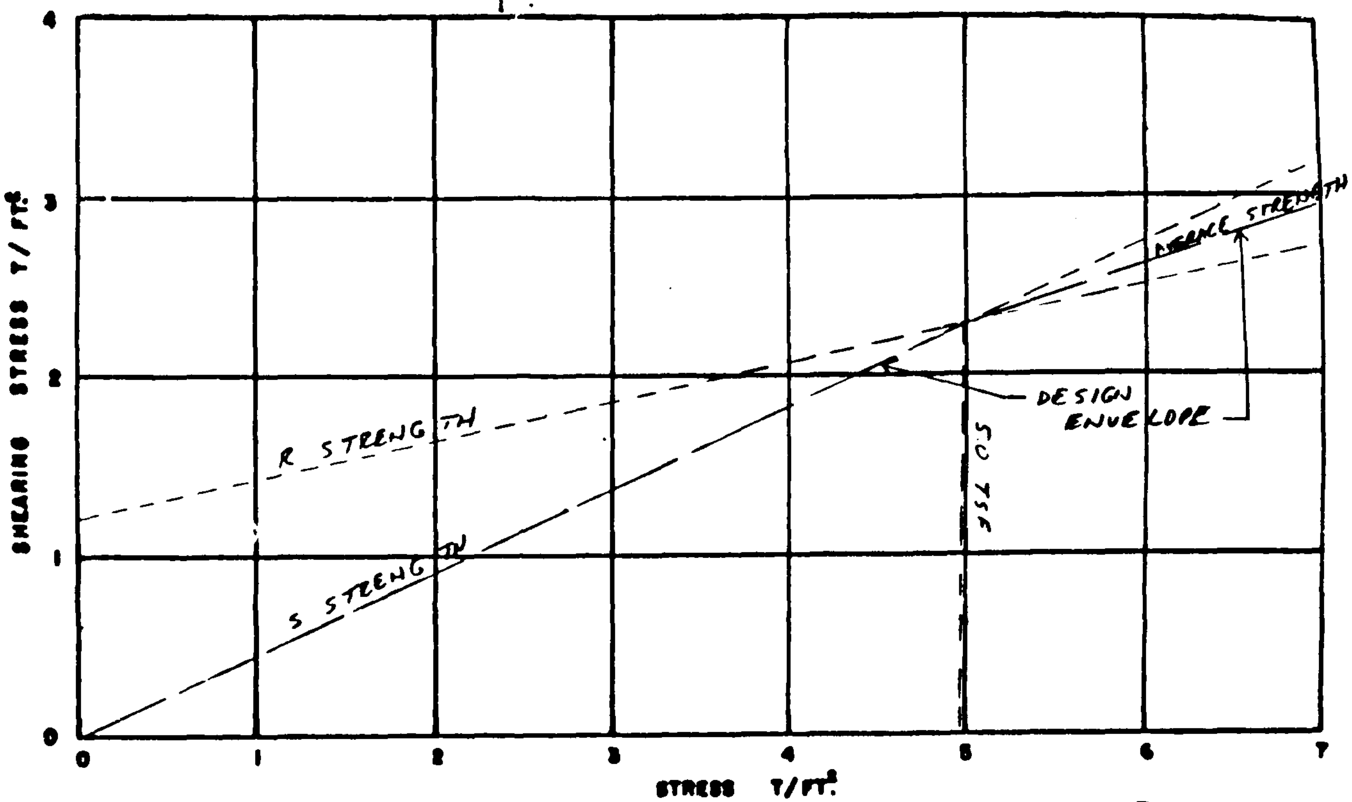
HOLE NO.	SAMPLE NO.	CLASS.	LL	PL.	TAN ϕ	C T/FT^2	γ_m PCF	γ_s PCF	REMARKS
	DM 5-	DESIGN	TESTS	(26.6°)	.500	0	130.0	133.0	—
				(21.9°)	.402	0.2			
	RECORD	TESTS		(24.8°)	.463	0	134.4	136.3	—
				(18.6°)	.343	0.6	TRANSITION AT 5 TSF = 10,000 PSF		
							FOR MOIST CONDITION, $H = \frac{10,000 PSF}{134.4 PCF} = 74 ft$		
							FOR SAT. CONDITION, $H = \frac{10,000 PSF}{73.9 PCF} = 135 ft$		

*

DM PLATE 13

IMPERVIOUS CORE SHEAR STRENGTH

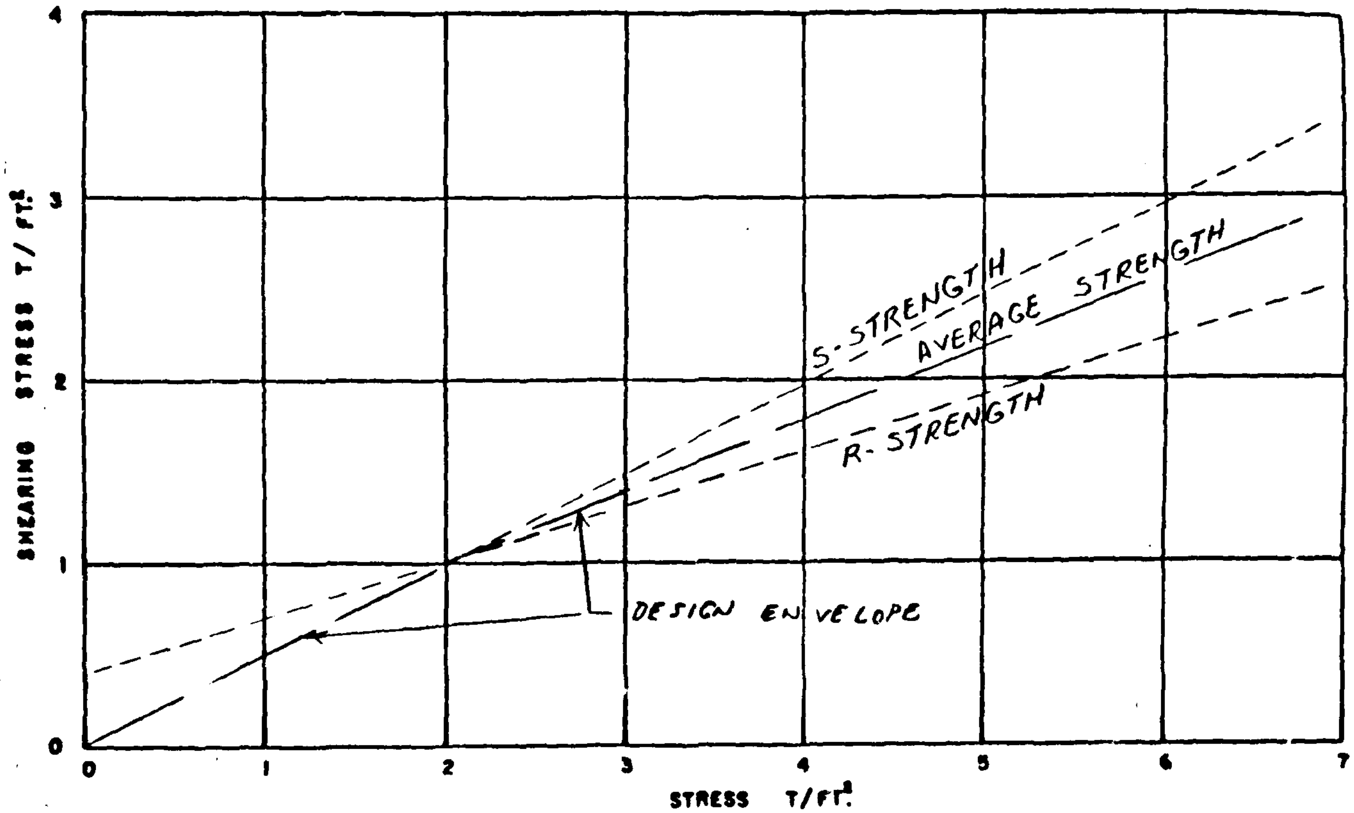
HARSHA LAKE OHIO
IMPERVIOUS CLAY CORE
RECORD R, S + COMPOSITE STRENGTHS



WM. HARSHA LAKE, OHIO - RECORD TESTS ON IMP. CLAY CORE

HOLE NO.	SAMPLE NO.	CLASS.	LL PL	TAN φ	C T/FT²	REMARKS
			"R"-STRENGTH	0.222	1.20	γ_M = 134.4 PCF
			"S"-STRENGTH	0.463	0.	γ_S = 136.3 PCF
		AVERAGE	STRENGTH	0.343	0.60	γ_B = 72.0 PCF

HARSHA LAKE, OHIO
IMPERVIOUS CLAY CORE
DESIGN R, S + COMPOSITE STRENGTHS



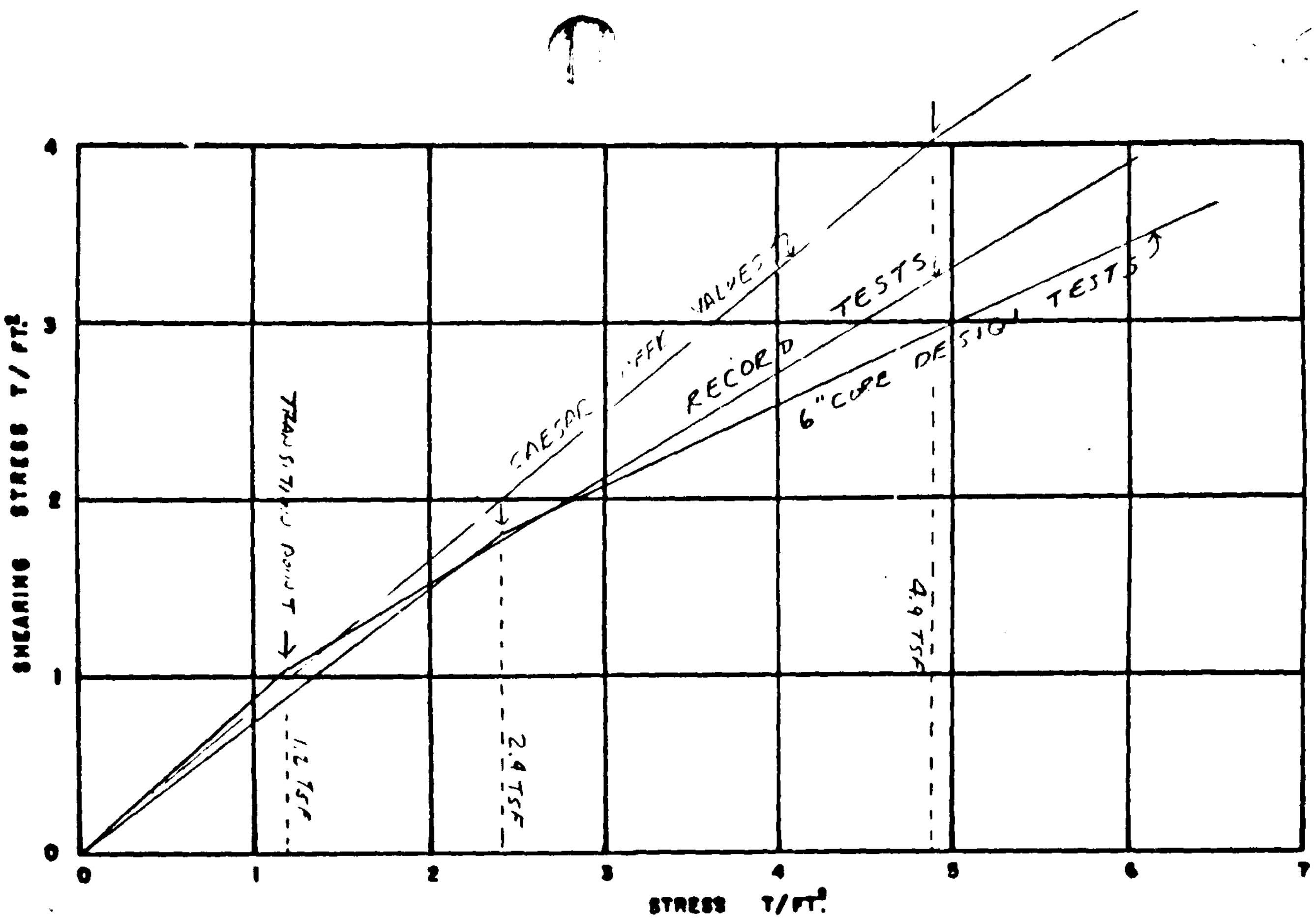
WM. HARSHA LAKE, OHIO - DESIGN TESTS ON IMP. CLAY CORE

HOLE NO.	SAMPLE NO.	CLASS.	LL	PL	TAN ϕ	C T/FT²	ϕ	REMARKS
			"R" STRENGTH		0.310	0.4	17.2	$\gamma_M = 130.0$ pcf
			"S" STRENGTH		0.501	0	26.6	$\gamma_S = 133.0$ pcf
		AVERAGE	STRENGTH		0.402	0.21	21.9	$\gamma_B = 70.6$ pcf

HARSHA LAKE, OHIO

RANDOM ROCK

COMPARISON (DESIGN ENVELOPE VS RECORD TEST ENVELOPE)



STRENGTH ENVELOPES

HOLE NO.	SAMPLE NO.	CLASS.	LL PL	TAN φ	C T/FT²	γm pcf	γs pcf	REMARKS
		6" CORE	DESIGN TESTS	.754	0	132.0	140.0	RUN TOO LATE TO BE USED IN DESIGN
TRANSITION AT	1.2 TF = 2400 PSF			.462	0.1			
FOR UNSAT CONDITION H = 2400/140.0 = 17 Ft		RECORD	TESTS (unsat)	.893	0	140.0	152.2	USED IN
FOR SAT CONDITION H = 2400/87.6 = 27 Ft			(CORE SAMPLES)(sat)	.601	0.35			STABILITY ANALYSES
		CAESAR CREEK (TP-370) VALUES		.837	0	127	139	USED IN EAST FORK
		RDM5		.445	0.8			DESIGN RMS

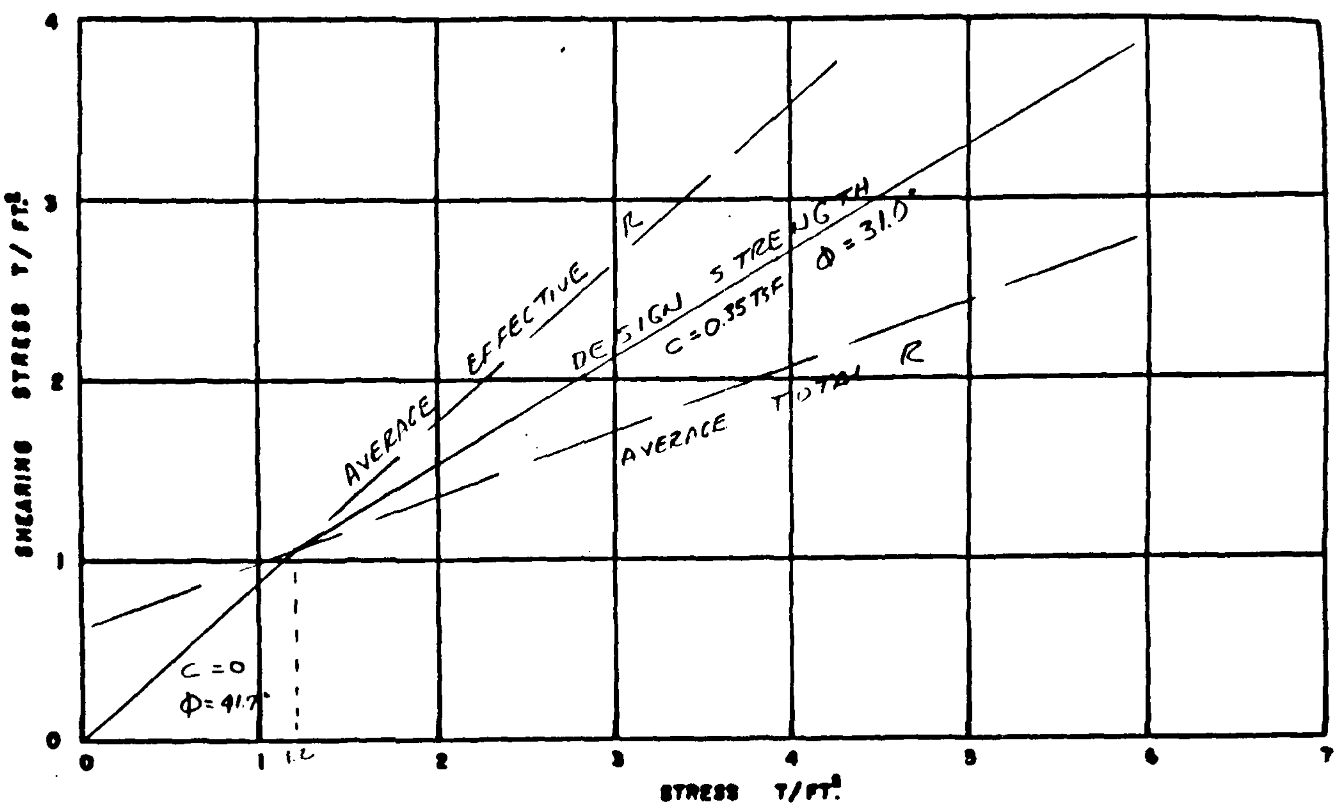
DM

PLATE 116

HARSHA LAKE OHIO

RECORD TESTS- RANDOM ROCK

DESIGN ENVELOPE



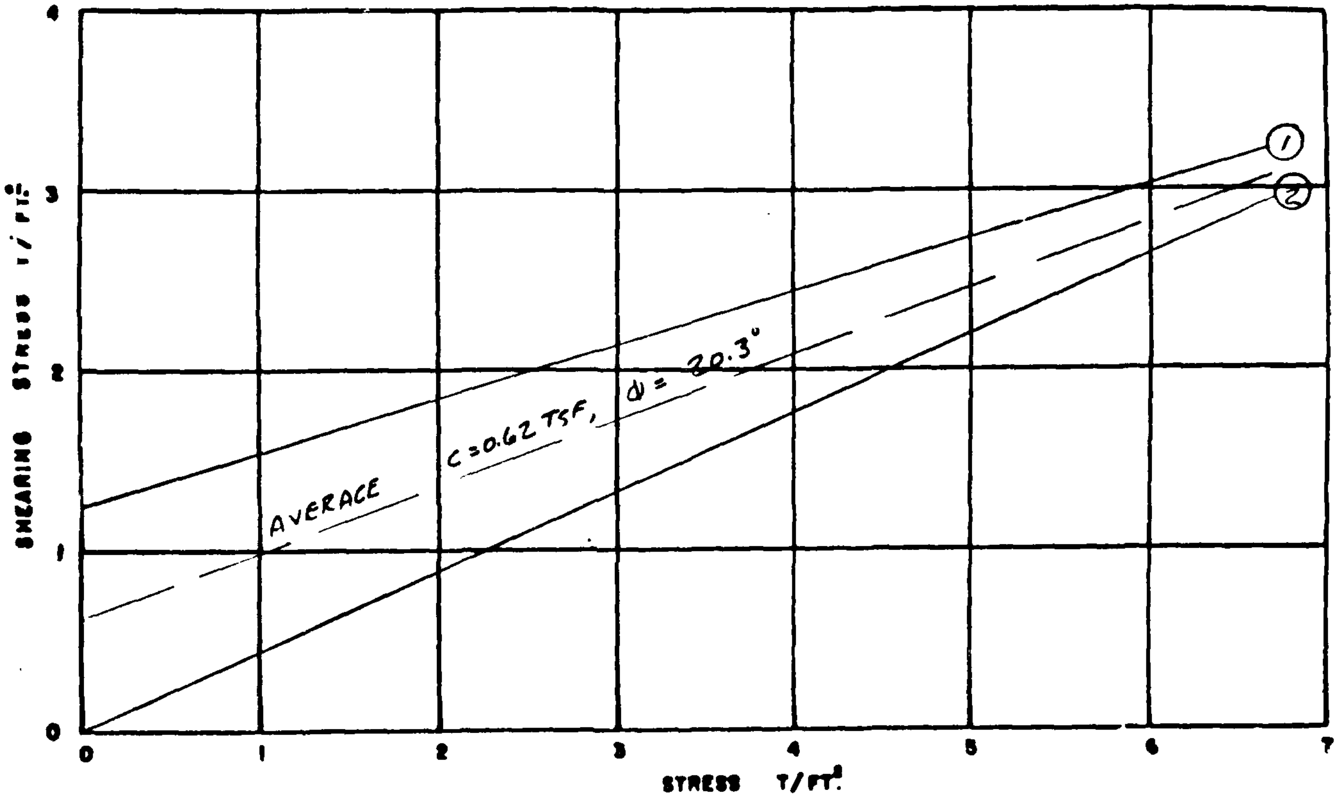
HOLE NO.	SAMPLE NO.	CLASS.	LL	PL	TAN Φ	C T/FT²	REMARKS
	AVERAGE	EFFECTIVE	R		.893	0.	
	AVERAGE	TOTAL	R		.371	0.62	
							γ_M = 140.0 PCF
	DESIGN	ENVELOPE			.601	0.35	γ_s = 132.2 PCF

DM

HARSHA LAKE, OHIO

RECORD TESTS - RANDOM ROCK

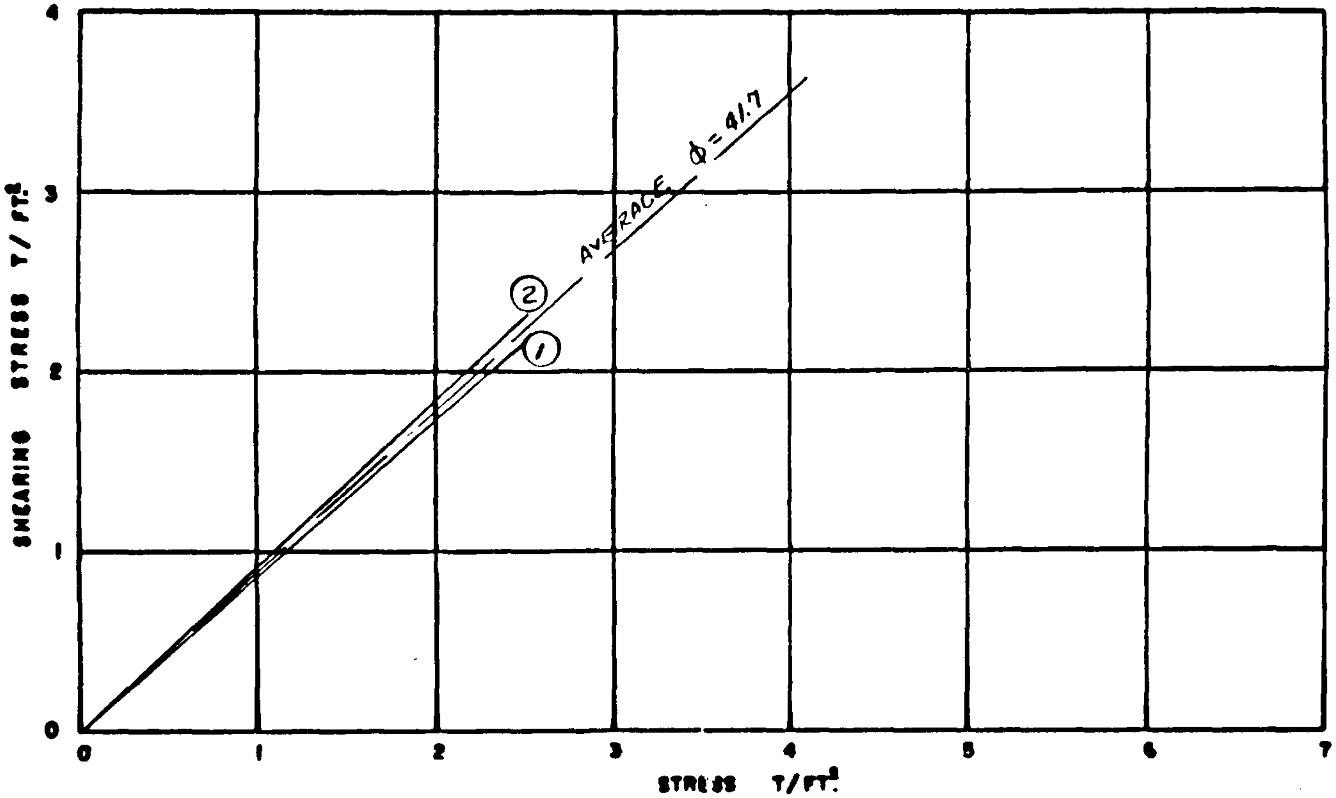
R TEST (TOTAL STRESS)



R STRENGTHS

HOLE NO.	SAMPLE NO.	CLASS.	LL	PL	TAN ϕ	C T/FT²	γ_M PCF	γ_S PCF	REMARKS
TP-1025		GC	35	19	.296	1.25	140.0	151.6	EL 825± 1
TP-1026		GC	29	17	.445	0	140.0	152.8	EL 795± 2
AVERAGE	TOTAL	R		(20.3)	.371	0.62	140.0	152.2	

HARSHA LAKE, OHIO
RECORD TESTS - RANDOM ROCK
R TEST (EFFECTIVE STRESS)



S STRENGTHS

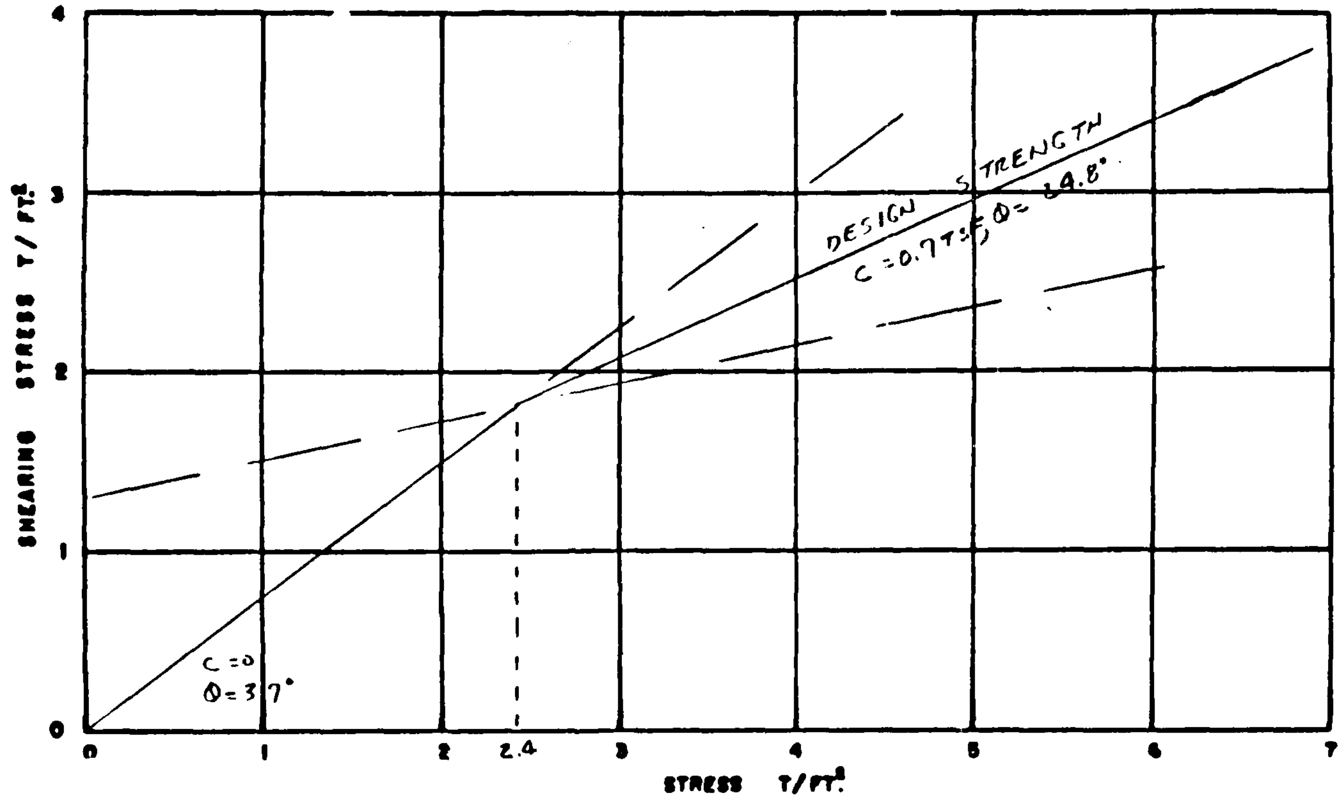
HOLE NO.	SAMPLE NO.	CLASS.	LL	PL	TAN ϕ	C T/FT²	γ_M PCF	γ_{SAT} PCF	REMARKS
TP-1025		GC	35	19	.869	0	140.0	151.6	EL. 825± (1)
TP-1026		GC	29	11	.916	0	140.0	152.8	EL. 795± (2)
AVERAGE	EFFEC	TIVE R		(41.9)	.893	0	140.0	152.2	

DM

HARSHA LAKE OHIO

6" CORE DESIGN TESTS – RANDOM ROCK

DESIGN ENVELOPE



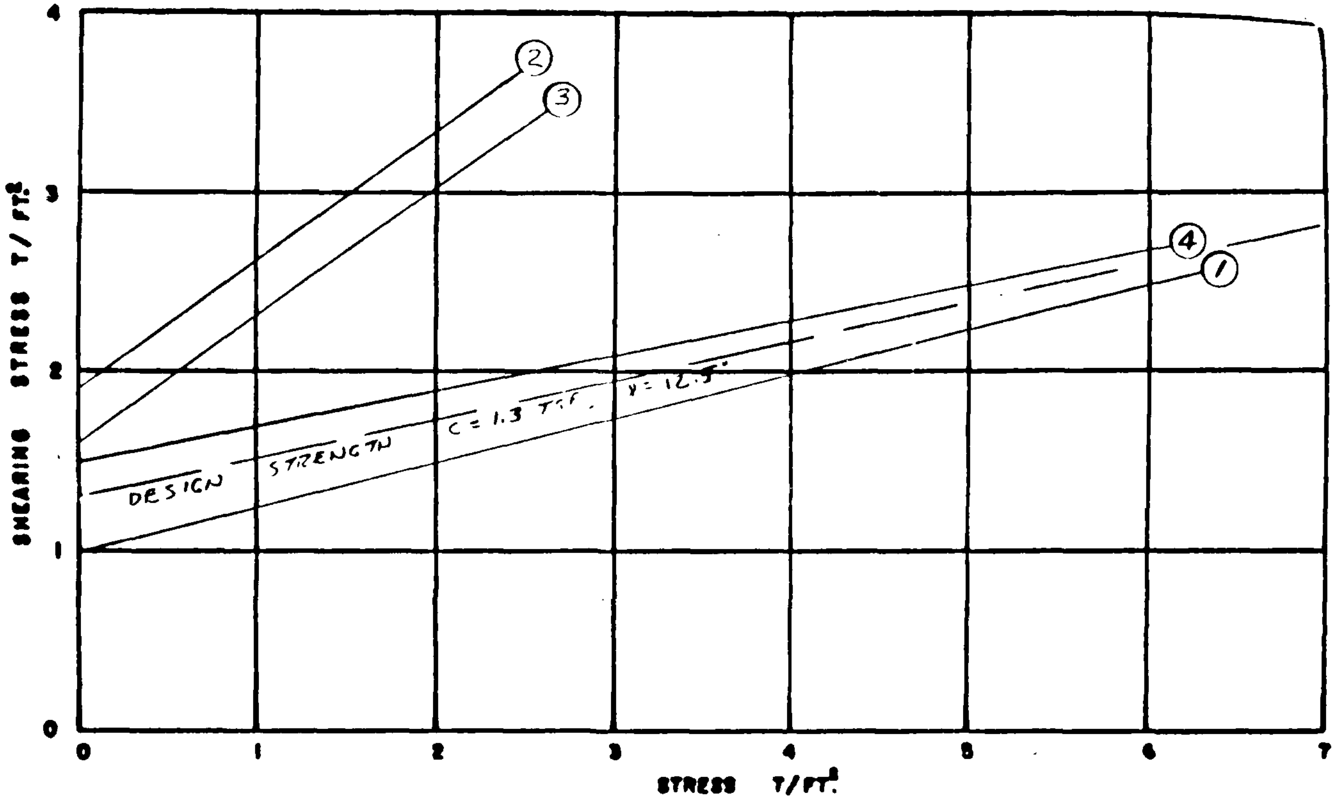
HOLE NO.	SAMPLE NO.	CLASS.	LL PL	TAN ϕ	C T/FT²	REMARKS
		DESIGN	R STRENGTH	.222	1.3	
		DESIGN	R' STRENGTH	.754	0.	
		DESIGN	ENVELOPE	.462	0.1	γ_M = 132.0 PCF
						γ_S = 140.0 PCF

DM

HARSHA LAKE, OHIO

6" CORE DESIGN TESTS - RANDOM ROCK

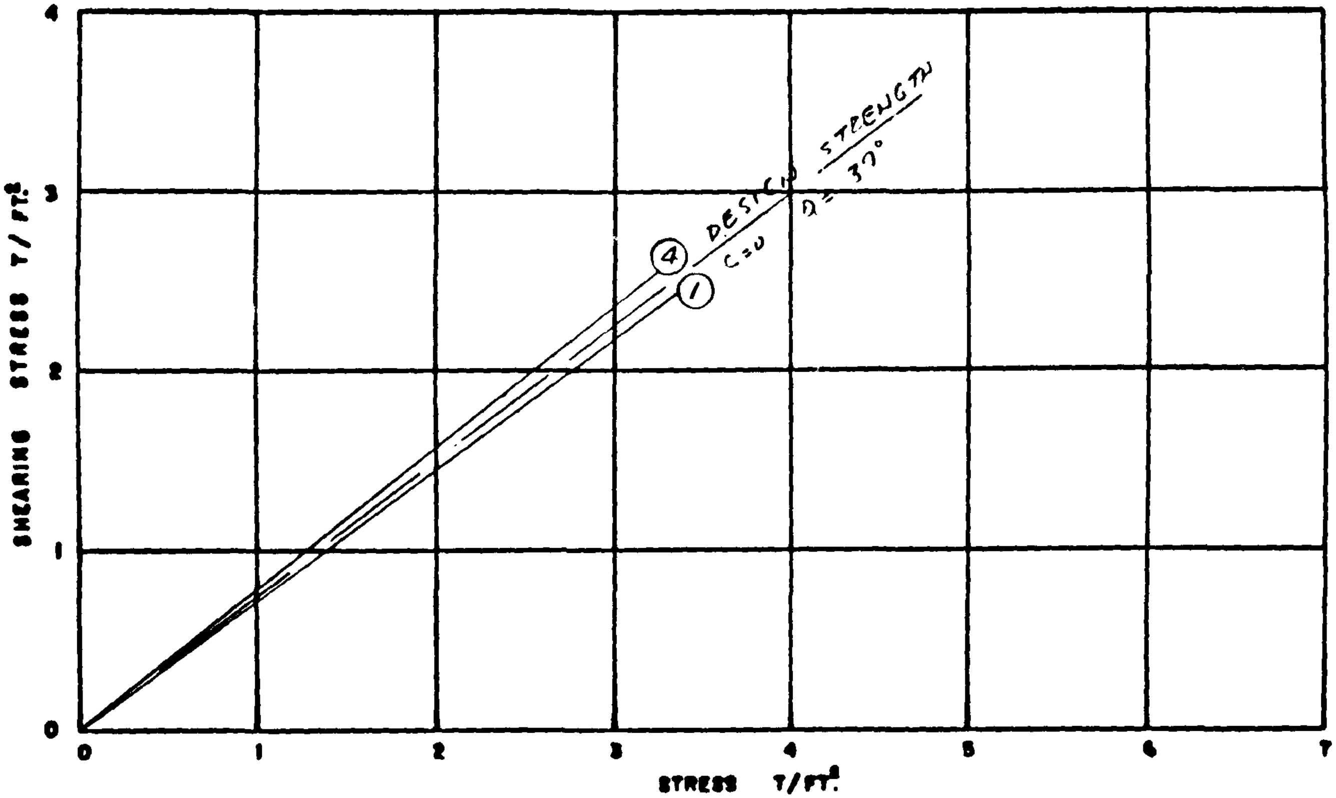
R TESTS



R STRENGTHS

HOLE NO.	SAMPLE NO.	CLASS.	LL	PL	TAN φ	C T/FT²	γ_M PCF	γ_S PCF	REMARKS
FC-1006 FC-1012	1	GW	30	16	.249	1.0	132.0	138.9	
FC-1014	2	GW	30	16	.727	1.9	132.0	135.1	
FC-1017	3	GW	30	16	.713	1.6	132.0	136.7	
FC-1118	4	GW	30	16	.203	1.5	132.0	149.2	
		DESIGN	STRENGTH R		.222	1.3	132.0	140.0	

HARSHA LAKE, OHIO
6" CORE DESIGN TESTS - RANDOM ROCK
R TESTS (EFFECTIVE STRENGTH)



S STRENGTHS

HOLE NO.	SAMPLE NO.	CLASS.	LL	PL	TAN Φ	C T/FT²	γ_M PCF	γ_S PCF	REMARKS
FC-1116 FC-1012	1	GW	30	16	.727	0	132.0	138.9	
FC 1118 FC 1111 FC 1015	4	GW	30	16	.781	0	132.0	149.2	
		DESIGN	STRENGTH	S	.754	0	132.0	144.0	

DM

APPENDIX A

TYPICAL CONSTRUCTION EQUIPMENT LIST

TYPICAL CONSTRUCTION EQUIPMENT LIST

The equipment listed below was in use during construction

- 9 Caterpillar 666 Scrapers
- 4 Caterpillar 631 Scrapers
- 6 Caterpillar 641 Scrapers
- 3 Caterpillar 637 Scrapers
- 2 Hyster Self-Propelled Compactors
- 3 Caterpillar 16 Graders
- 2 Bros 50 Ton Rollers
- 1 Manitowoc 2000 Crane
- 1 Grove Hydraulic Crane
- 2 Rome Disks
- 2 Water Trucks
- 1 Caterpillar 631 Water Tanker
- 1 G1000 Gradall
- 5 Caterpillar D-8 Dozers
- 7 Caterpillar D-9 Dozers
- 1 Caterpillar D-6 Dozer
- 1 74 Cougar Tractor
- 2 Caterpillar 463E Scrapers
- 2 Caterpillar 977 Endloaders
- 7 Alamo Light Plants
- 2 RayGo Vibratory Rollers
- 2 Lube Trucks
- 15 Pickup Trucks
- 2 Flat Bed Trucks
- 4 Lincoln Welders
- 2 Davey Drill Rigs

APPENDIX B

PHOTOGRAPHS

Photo 1

Saddle Dam, Impervious Fill. Sta 20+00 looking ahead. Shows 2 Hyster rollers, disking, spreading and dumping operations. Blue till material being processed. (Nov 1973)

Photo 2

Saddle Dam, Impervious Fill. Sta 30+00 looking back. Spreading and rolling operations on brown till material (blue and brown till - two types used). (Oct 1973)

Photo 3

Saddle Dam, Impervious Fill. Typical disking operation. (Oct 1973)

Photo 4

Saddle Dam, Vertical Sand Drain. Digging vertical sand drain with G1000 Gradall. (Oct 1973)

Photo 5

Saddle Dam, Vertical Sand Drain. Vertical drain showing RayGO vibratory roller at far end of trench. (Oct 1974)

Photo 6

Saddle Dam, Vertical Sand Drain. Vertical drain showing hand vibratory plates, stockpiles of sand. (Water truck and endloader for charging sand at far center of photo.) (May 1975)

Photo 7

Saddle Dam, Horizontal Sand Drain. Horizontal finger drain downstream (left) of ±Sta 20+00. This was the main horizontal drain. Photo shows spreading and rolling operation. (Jul 1973)

Photo 8

Saddle Dam, Horizontal Sand Drain. Typical excavation of a finger drain area with G1000 Gradall. (June 1973)

Photo 9

Saddle Dam, Horizontal Drains. Shows excavation for horizontal finger drain D/S toe of Saddle Dam between Stations 24 to 26. Looking North. (Jul 1973)

Photo 10

Saddle Dam, Horizontal Drain. Shows horizontal drain material D/S of Sta ±28+00 being covered with impervious. (Oct 1973)

Photo 11

Saddle Dam, Horizontal Sand Drains. Shows stockpiling of drain material and roller used in horizontal finger drains. (Sep 1973)

Photo 12

Saddle Dam, Horizontal Sand Drains. Typical end dumping of material into horizontal finger drain D/S of ±Sta 25+00. (Jun 1973)

Photo 13

Saddle Dam, Waste Berm. D/S waste berm. Sta ±25+00 saddle dam looking southwest. (Mar 1976)

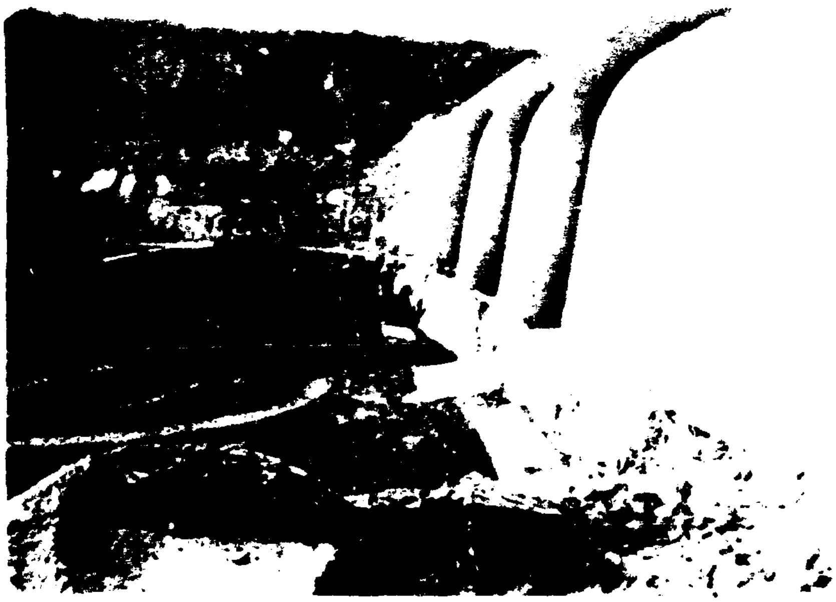
Photo 14

Saddle Dam, Waste Berm. D/S waste berm. Sta ±29+00, saddle dam looking south. (Mar 1976)

Photo 15

Saddle Dam, Waste Berm. U/S waste berm. Sta ±20+00 looking northeast. (Oct 1973)

Photo 16



Main Dam, Impervious Core. Hyster roller on impervious fill near conduit seep rings and foundation. (Oct 1974)

Photo 17

Main Dam, Impervious Core. Work on impervious core first two lifts off of foundation in area of conduit. (Oct 1974)

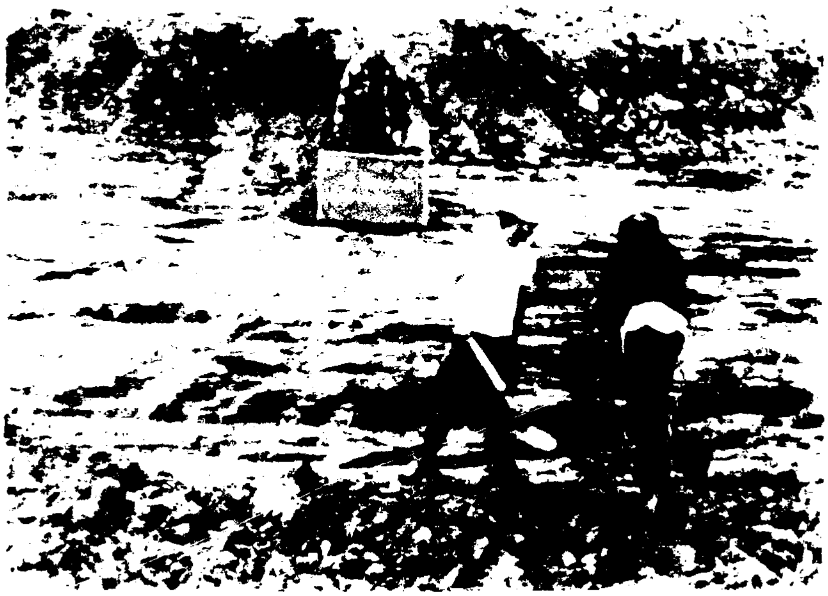
Photo 18

Main Dam, Impervious Core. Typical spreading on impervious core near dam foundation. (Oct 1974)

Photo 19

Main Dam, Impervious Core. Trimming and cleaning right abutment slope where impervious core tied in. (Nov 1974)

Photo 20



Main Dam, Impervious Core. Hand cleaning on right abutment where impervious core ties in. (May 1975)

Photo 21

Main Dam, Impervious Core. Hand backfill operations of impervious material along conduit. (Nov 1973)

Photo 22

Main Dam, Impervious Core. Impervious core material extended along conduit U/S to tower area through rock section. (Nov 1973)

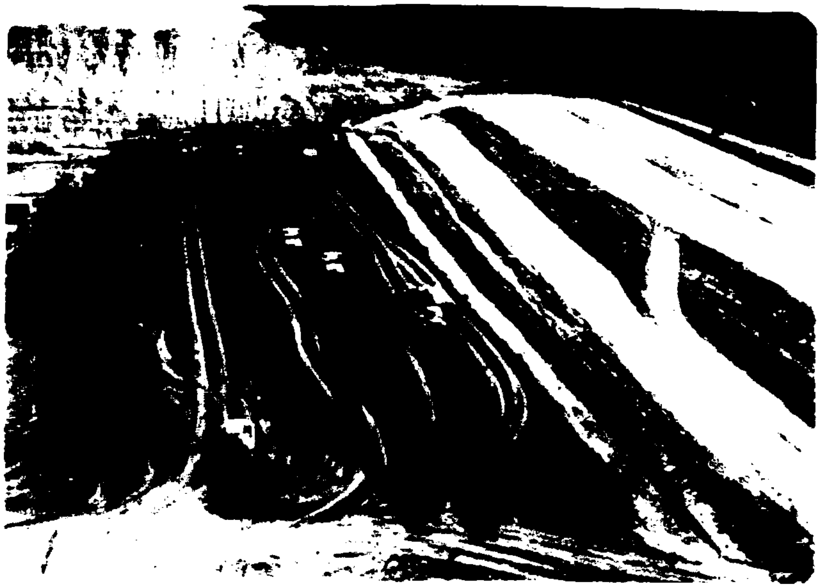
Photo 23

Main Dam, Impervious Core. View of impervious core disking, spreading and rolling operations. Looking from left abutment toward right abutment. (May 1975)

Photo 24

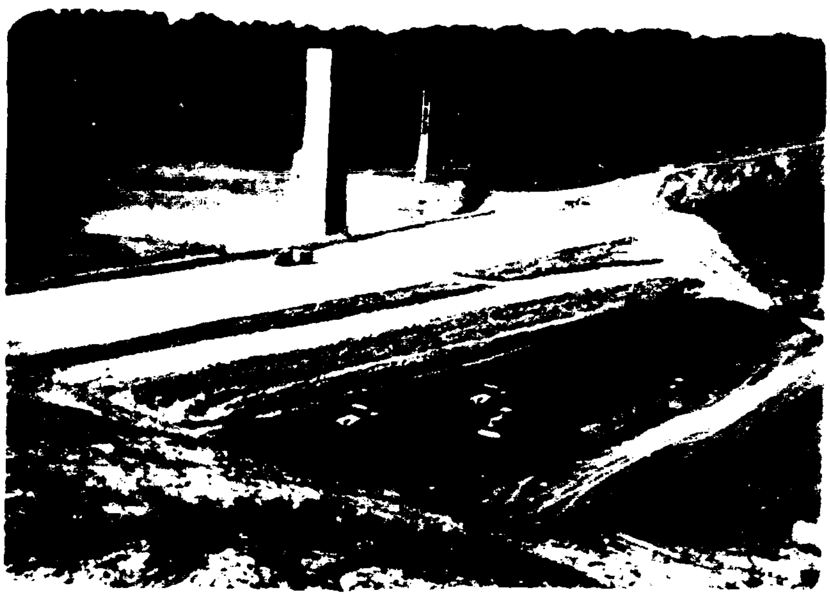
Main Dam, Impervious Core. View of core operations looking from right abutment to left abutment. Note random rock shale transition on upstream side of core material. (Jul 1975)

Photo 25



Main Dam, Random Earth Zone. Typical embankment operation. Looking from left abutment to right abutment. 1st and 2nd stage permanent rockfill coffers on U/S (right) side picture. (Oct 1974)

Photo 26



Main Dam, Random Earth Zone. Typical embankment operations of spreading, disking and rolling. Looking from right abutment to left abutment. (Oct 1974)

Photo 27

Main Dam, Random Rock Zones. Typical random rock zone operations. Shows dumping, spreading, 50-ton roller and Hyster roller. (Sep 1974)

Photo 28

Main Dam, Random Rock Zones. Typical operation depicting magnitude of equipment spread. (Sep 1974)

Photo 29

Main Dam, Random Rock Zones. Looking from left abutment to right abutment. Upstream rock coffers complete. Work progressing on downstream random rock zone. (Apr 1975)

Photo 30

Main Dam, Inclined Sand Drain & Transition Material. Photo depicts covering of previous sand drain lift with impervious material. (May 1975)

Photo 31

Main Dam, Inclined Sand Drain & Transition Material. Photo shows G1000 Gradall trimming back impervious material placed over previous sand and transition material. (Nov 1974)

Photo 32

Main Dam, Inclined Sand Drain & Transition Material. Gradall trimming impervious edge. Sand dumped in place. Back-up random rock placed. (Nov 1974)

Photo 33

Main Dam, Inclined Sand Drain & Transition Material. Shows watering, rolling, trimming impervious slope and placing material (sand and transition material with endloader). (Oct 1975)

Photo 34

Main Dam, Inclined Sand Drain & Transition Material. General photo of operations close to top of dam. (Nov 1975)

Photo 35

Main Dam, Horizontal Sand Drain. Dumping sand material in D/S foundation area. (Oct 1974)

Photo 36

Main Dam, Horizontal Sand Drain. Dumping, spreading and rolling horizontal drain material in main dam foundation area. (Nov 1974)

Photo 37

Main Dam, Horizontal Drain. Spreading sand downstream valley foundation. (Nov 1974)

Photo 38

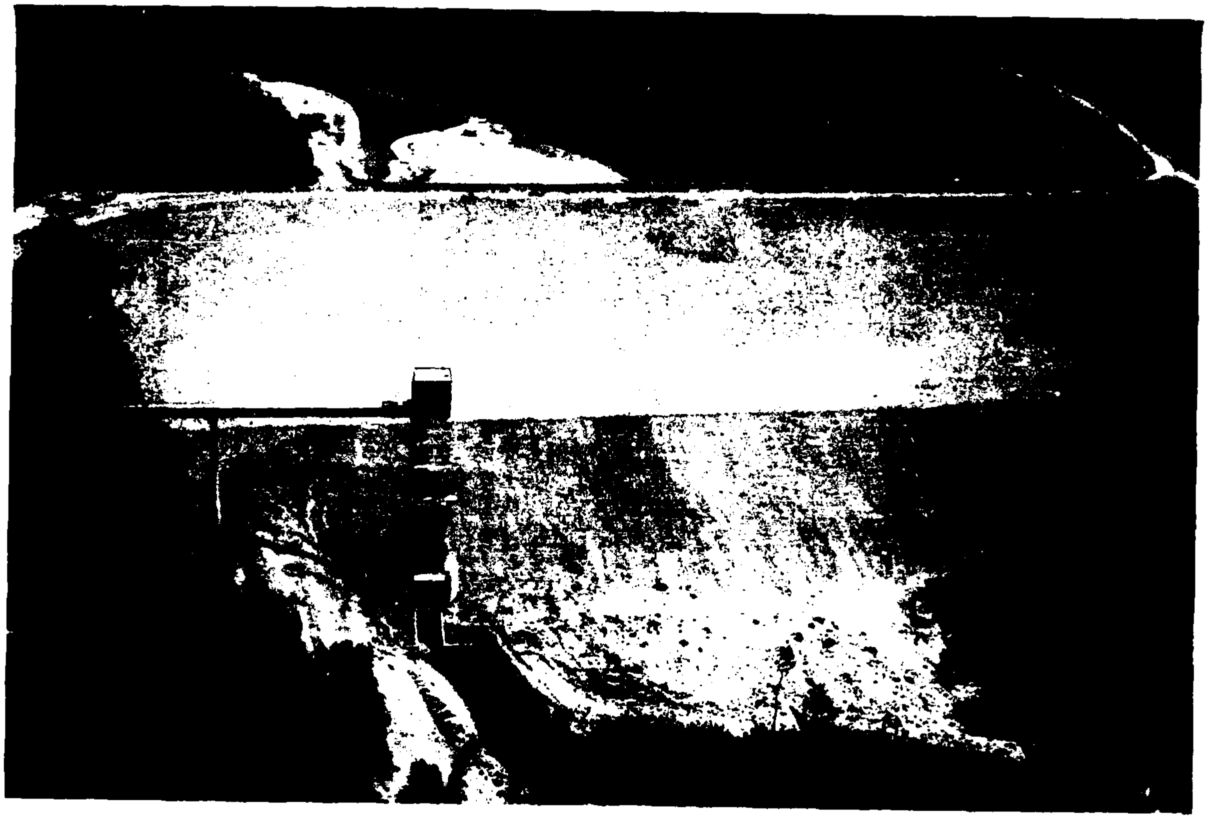
Main Dam, Horizontal Drain. Rolling horizontal drain material that covered abutments. Looking at right abutment. (Apr 1975)

Photo 39

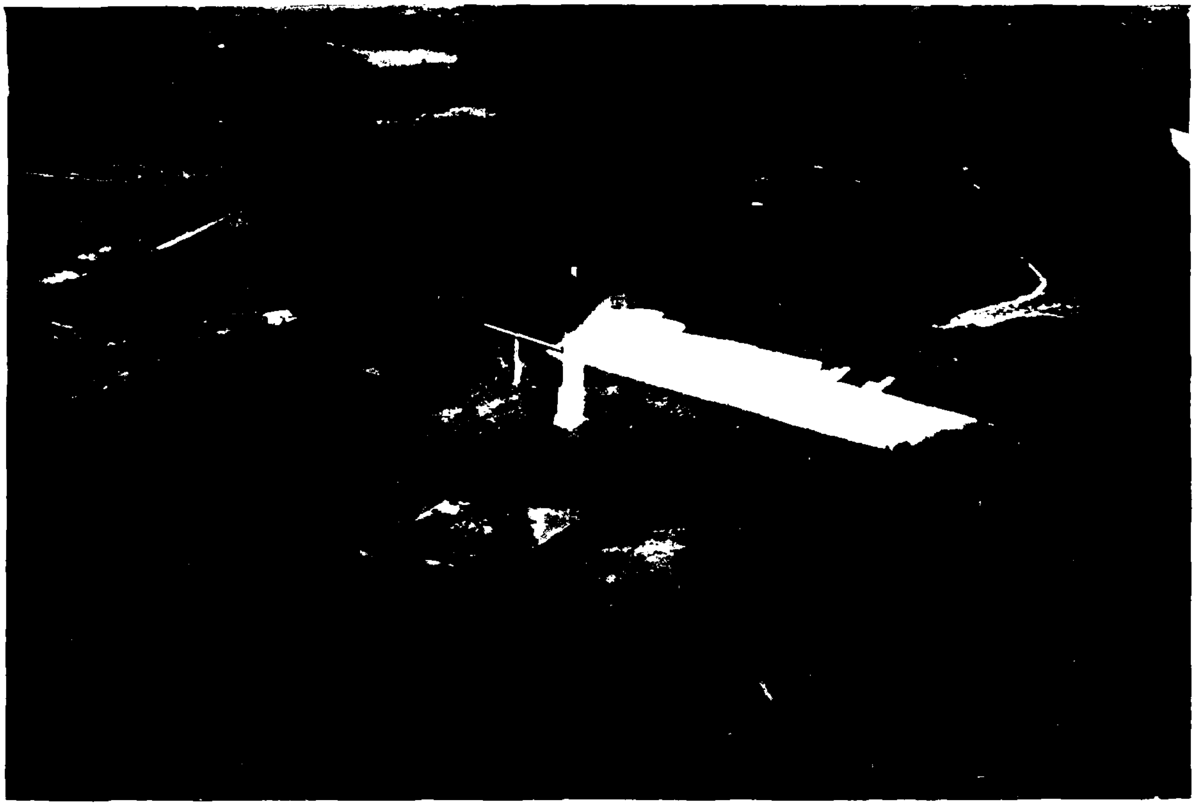
Main Dam, Diversion and Closure. Building temporary dike across main stream in foreground of picture. (Aug 1974)

Photo 40

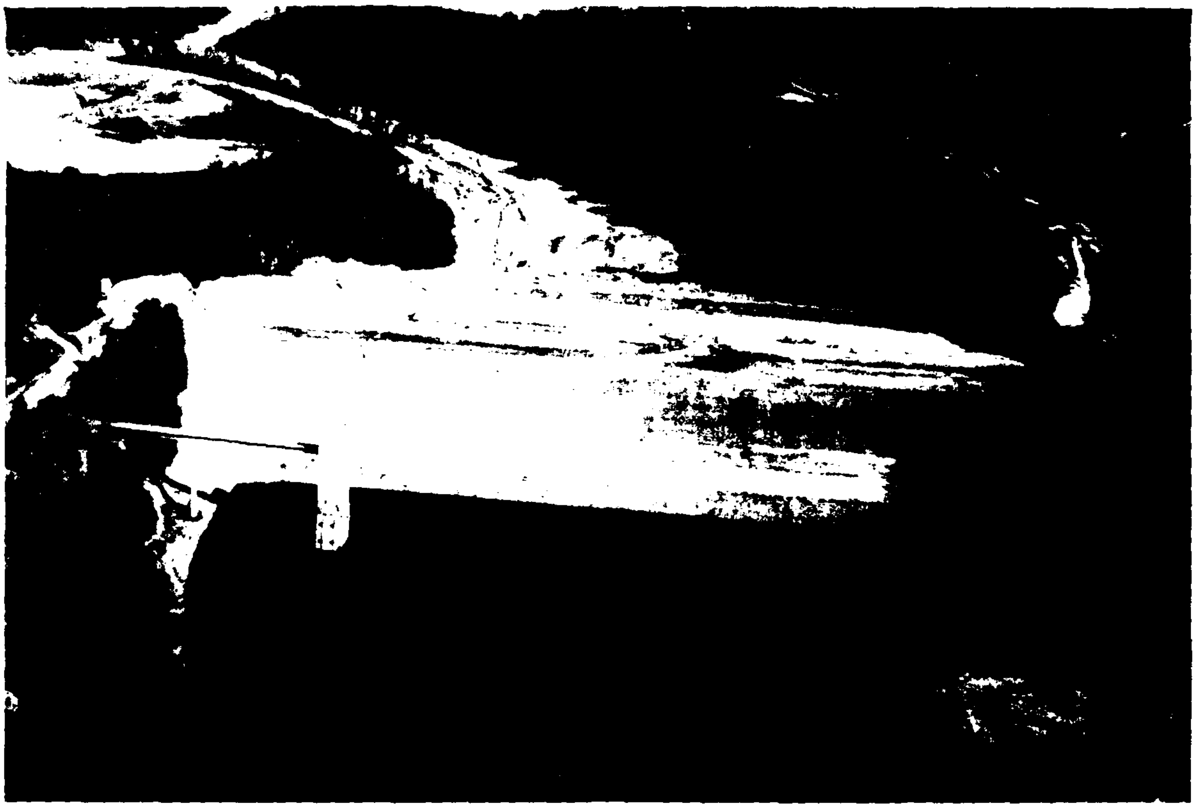
Main Dam, Diversion and Closure. Finishing temporary dike across main stream at top of photo. River starting to flow through outlet structure at bottom of photo. (Aug 1974)



WILLIAM H. HARSHA DAM (9 JUN 76)



WILLIAM H. HARSHA DAM (14 JAN 76)



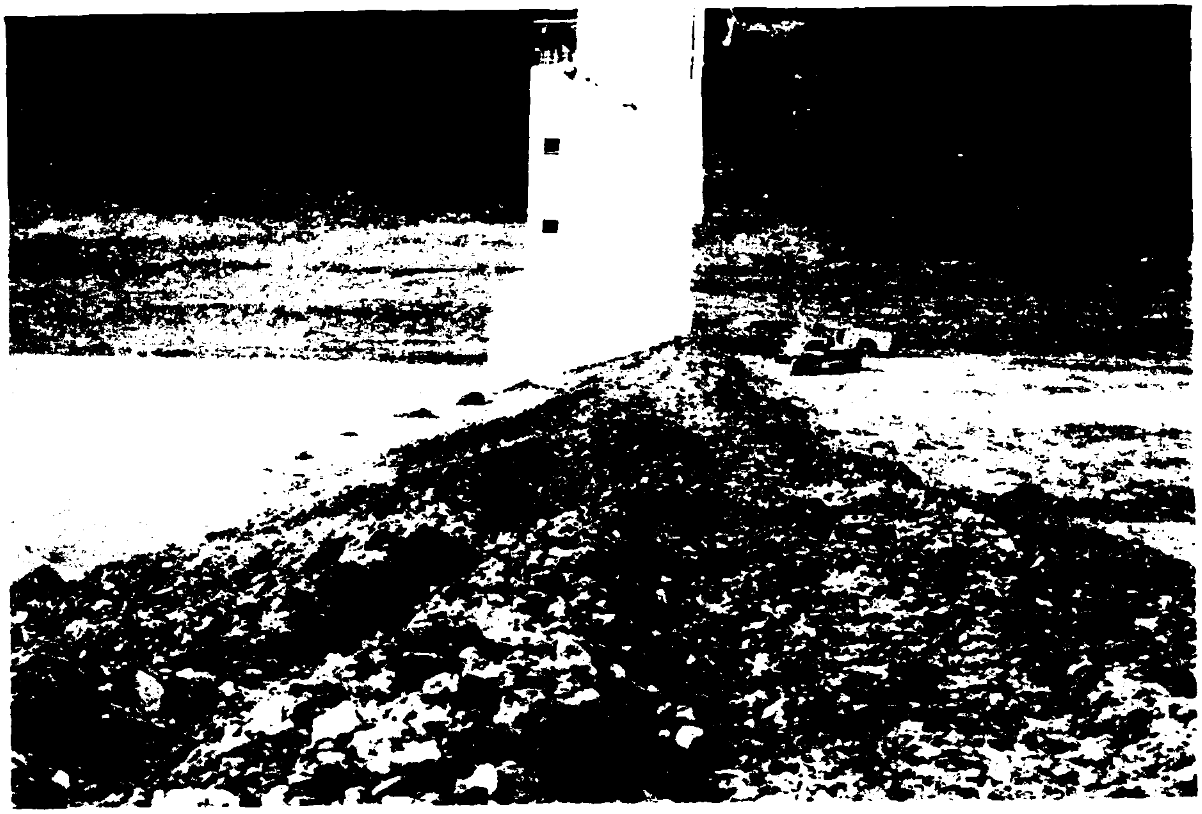
WILLIAM H. HARSHA DAM (22 OCT 75)

WILLIAM H. HARSHA DAM (20 MAY 75)

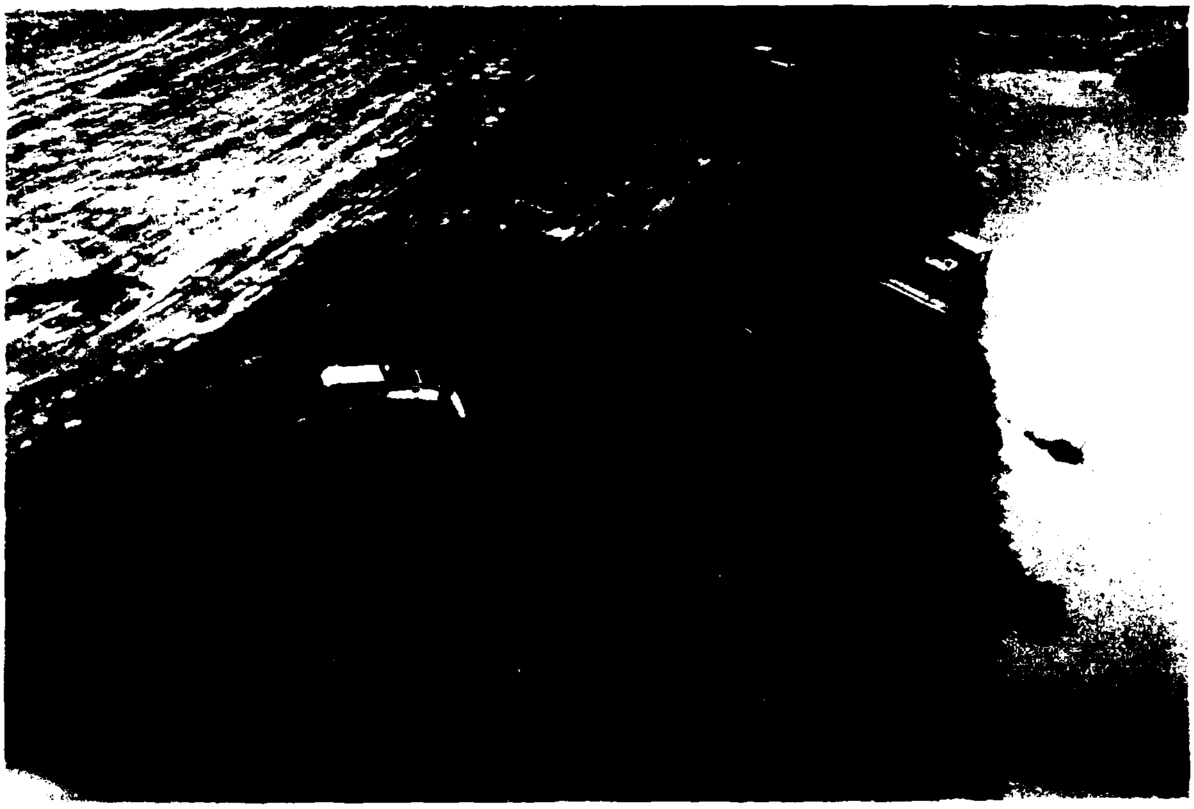
WILLIAM H. HARSHA DAM (20 MAR 75)

WILLIAM H. HARSHA DAM (20 MAR 75)

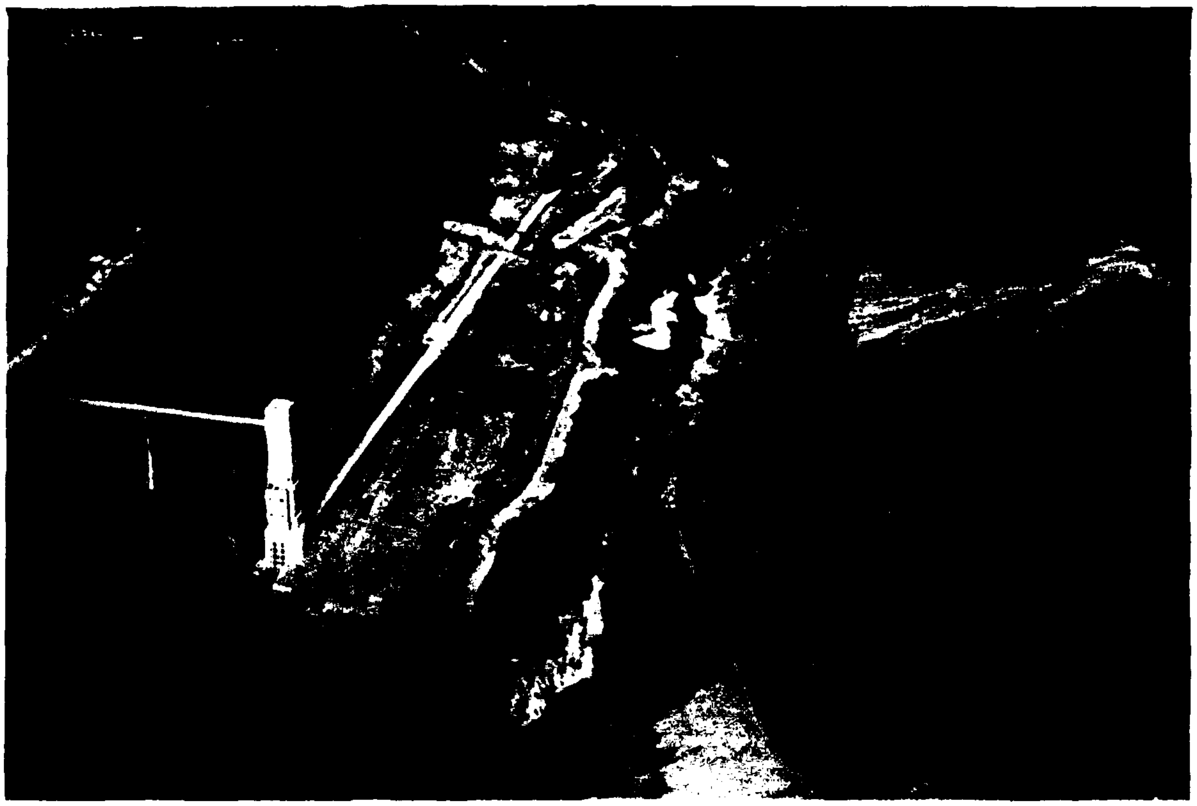
WILLIAM H. HARSHA DAM (1 OCT 74)



WILLIAM H. HARSHA DAM - LOOKING TOWARD
THE TOWER AND LEFT ABUTMENT (29 AUG 74)



WILLIAM H. HARSHA DAM - PLACING MATERIAL
ON THE PERMANENT COFFERDAM (9 AUG 74)



WILLIAM H. HARSHA DAM - PRIOR TO
DIVERSION THROUGH THE CONDUIT (5 MAR 73)